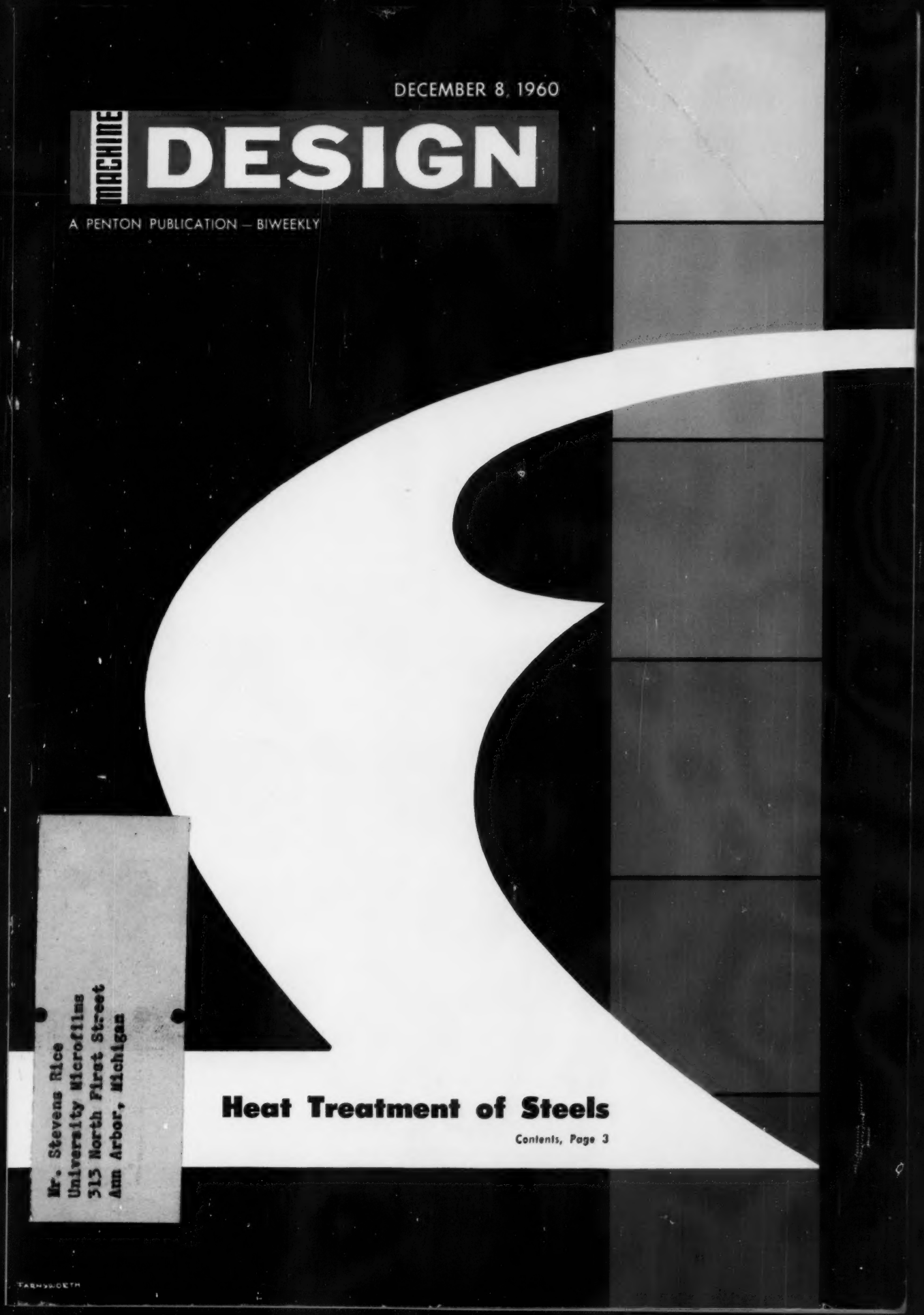
DECEMBER 8, 1960

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Heat Treatment of Steels

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Mr. Stevens Rice
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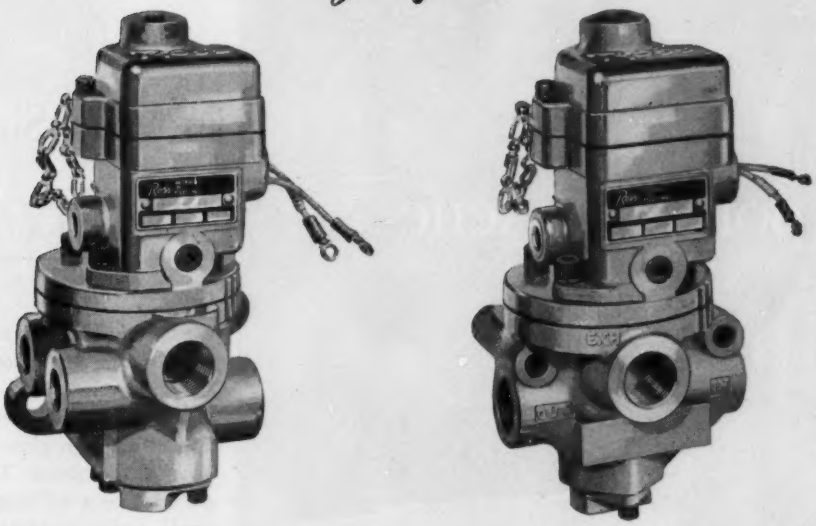

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Polypropylene makes better products at lower cost. No other material has this combination of properties:

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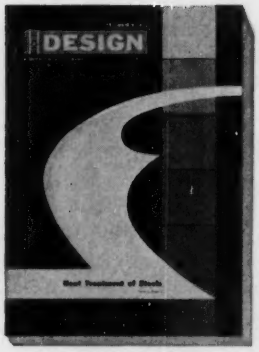

Front Cover: Color and curves lend a futuristic touch to artist George Farnsworth's interpretation of a typical isothermal transformation diagram for steel. The curves play a key role in Lester Spencer's graphic description of heat-treating methods, starting on Page 160.

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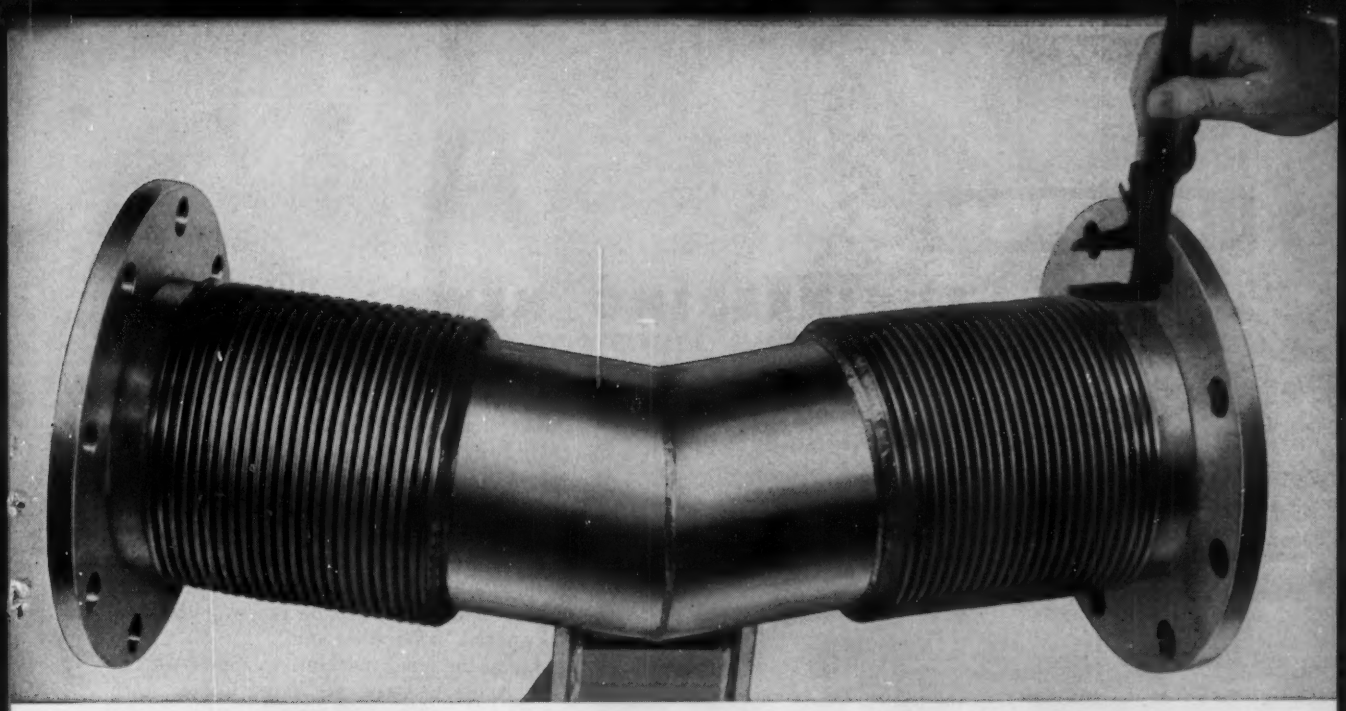

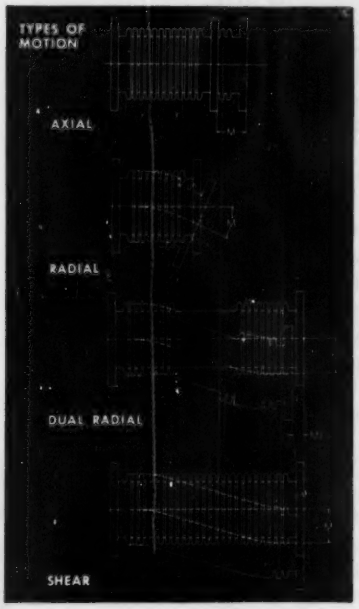

Expansion-joint tubing for big, tough jobs

New AX Tubing by Anaconda is available in Bronze, Stainless Steel, and other metals and alloys—from 4½" I.D. to 14" I.D.—to handle axial and lateral movement.

Need to compensate for contraction of piping suddenly cooled to minus 300°F by a large volume of liquefied gas? Want a bulkhead seal that "gives" with hull movement? Do you need a special assembly like that above, which handles an offset and a combination of lateral and axial movement? Wherever you need large diameter tubing to take care of movement shown in drawing at left, or simple offset, write: Anaconda Metal Hose, P.O. Box 791, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario. 80129 L

ANACONDA® METAL HOSE

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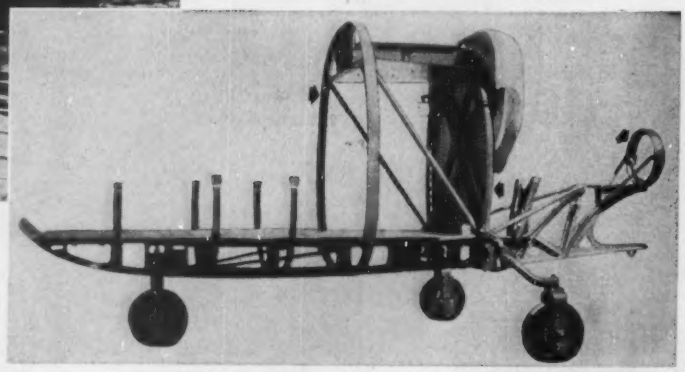
ENGINEERING NEWS

Pressure Jets Power New Civilian 'Copter



Unified structure similar to that used in automobiles simplifies assembly of the Monte-Copter. External skin covering for all areas except the wing is vacuum-molded fiber glass. Internal fuselage is made largely of magnesium, in the form of castings, extrusions, and sheet. Price: About $25,000

TO many enthusiastic proponents of VTOL aircraft, the ultimate goal is the introduction of a family-car concept in air travel. While this situation has not as yet been realized, small VTOL vehicles are becoming more and more promising for a wide range of commercial and civilian applications.

One of the latest machines to appear—it's in the prototype stage at Monte-Copter Inc., Seattle, Wash.—features important state-of-the art advances which should help further the cause of "off-highway" motoring.

The Monte-Copter is an amphibious helicopter built around the cold-cycle, pressure-jet rotor system. Thrust to turn the rotor is provided by air ejected at supersonic velocity through nozzles at the blade tips. The air supply is furnished by a gas-turbine engine mounted in the rear of the fuselage, with the tailpipe directed aft. The engine provides about 80 lb of horizontal thrust in flight, a factor that reduces thrust requirements of the rotor system by one-third. For taxiing on the ground (40 mph) or in water (10 mph), all air can be exhausted aft.

For the potential Monte-Copter pilot, a simplified control system, unparalleled in VTOL design, makes the craft extremely attractive. The tip-driven rotor produces no noticeable torque or yawing tendency, so the usual tail rotor has been eliminated. A conventional aircraft rudder is used for directional control, with ailerons on the wing trailing edge co-ordinated to operate with the rudder pedals.

Monte-Copter's conventional stressed-aluminum wing provides 25 per cent of the required lift during maximum forward speed.

...Fluid Power news

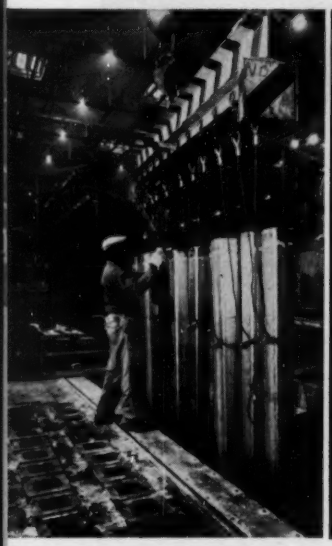
REPORT NO. 11,805 CASTING FEEDS NOT AFFECTED BY LOAD VARIATIONS

From Oilgear *Application-Engineering* Files

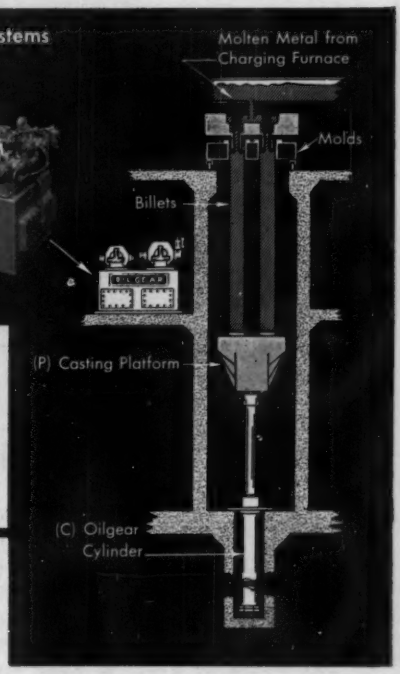
HOW OILGEAR SYSTEMS IN KAISER ALUMINUM PLANTS AID DIRECT CHILL BILLET CASTING PRODUCTION

USER: *Kaiser Aluminum & Chemical Corporation*

PROBLEM: To supply direct chill billet casting platform power and control systems for production of a major portion of the 1,050,000,000 lb of aluminum consumed annually by domestic extruders. Direct chill billet quality — avoidance of internal cracking, homogeneity, grain structure fineness and orientation — depends on a smooth, unvarying, precise platform feed rate, careful control of pouring speed and temperature, cooling rate, and other variables to prevent atmospheric oxidation and impurities. Up to 32 billet logs over 18 ft long are to be produced in a single cast. POWER AND CONTROL SYSTEM REQUIREMENTS: 1. Remote pushbutton control of all functions. 2. Rapid platform traverse up and down. 3. Infinite "down" feed rate selection — unvarying regardless of casting platform load increase; chatter-free — unaffected by off-balance platform loads. 4. "Fail-safe" — insuring completion of a cast in event of power failure. 5. Must be simple, and assure long, trouble-free, dependable service.



Application-Engineered Fluid Power Systems For Direct Chill Casting Stations



HOW IT WORKS: The Oilgear Variable Displacement Pump (1) on "Power-Pak" (A) provides adjustable preset slow and fast speeds for raising and lowering casting platform (P). Oilgear Variable Displacement Piston-type Precision Metering Pumps (2) are connected in series hydraulically between Oilgear Cylinder (C) and "Power-Pak" (A) Reservoir. Ram down-feed during casting is dependent upon control setting of the Secondary Metering Pump — remotely pushbutton-controlled to provide instant, precise, feed rate adjustment... indicated in ipm on a direct reading indicator. Oil, increasing in pressure as the billet load increases, flows from Cylinder (C) through sealed, "pressurized," Primary Metering Pump — and then, at relatively constant low pressure, through the Secondary Metering Pump to "Power-Pak" (A) Reservoir — providing an extremely accurate casting feed rate regardless of varying platform load. An automatic, Oilgear hydraulic control varies Primary Metering Pump displacement to compensate for load variation and feed rate selected. "Fail-safe" operation is provided through Oilgear Valves.

Above: Rapid traverse is used to raise the casting platform, bringing, in this case, the 6-in.-sq. by 18-ft billet logs out of the casting pit for identification with cast number at one of three direct chill casting stations at Kaiser Aluminum's Chalmette, La., Works. Direct chill "molds" are clearly visible behind the "marker."

SOLUTION: Oilgear's patented Feed and Control System provides accurate volumetric metering of pressurized oil over a 200:1 pressure range, and a 100:1 feed range. Installations consist of an Oilgear Variable Displacement Pump direct-connected to an electric drive motor, two Oilgear Precision Variable Displacement Metering Pumps direct-connected to a double-end synchronous electric motor — all mounted on a custom-built reservoir base (A); and Oilgear piston- and ram-guided, chatter-free, *Custom-Quality* Cylinder (C); Oilgear Valves and Controls... all thoroughly, carefully *Application-Engineered.*

USER REPORTS — "Where accumulating load on the platform varied oil pressure from 50 to 1500 psi, and the rate of metering was preset anywhere from 50 to max. cipm, *there was no measurable change on the preset rate of casting feed during any portion of the stroke.*"

There has been NO major maintenance on these heavy-duty Oilgear Systems operating continuously in Kaiser Aluminum plants across the nation — some for over 7 years — and still "going strong."

THIS PATENTED OILGEAR METHOD of precise metering — and other accurate Oilgear Control Systems — have been applied to a wide range of applications in many industries where varying loads must not affect the speed of linear movement or hydraulic motor rotation. Carefully Application-Engineered Oilgear Systems — also used extensively on extrusion presses... aluminum foil laminating machines... stretching, forming, drawing and spinning presses... can-closing and filling machines... metal briquetting presses... ladle tilting, ingot manipulators, strippers, and scalpers — have all proved Oilgear equipment's traditionally long life, prompting users to state —

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Waste-heat utilization jumps performance for

Exotics in Tandem

SCHENECTADY, N. Y.—A combination thermionic-thermoelectric energy converter now in the laboratory may be the forerunner of "exotic" electrical generators that can produce practical quantities of power. Waste heat rejected by the thermionic half of the unit is utilized by the thermoelectric device. Output and efficiency of the combination are significantly higher than those of single-stage generators.

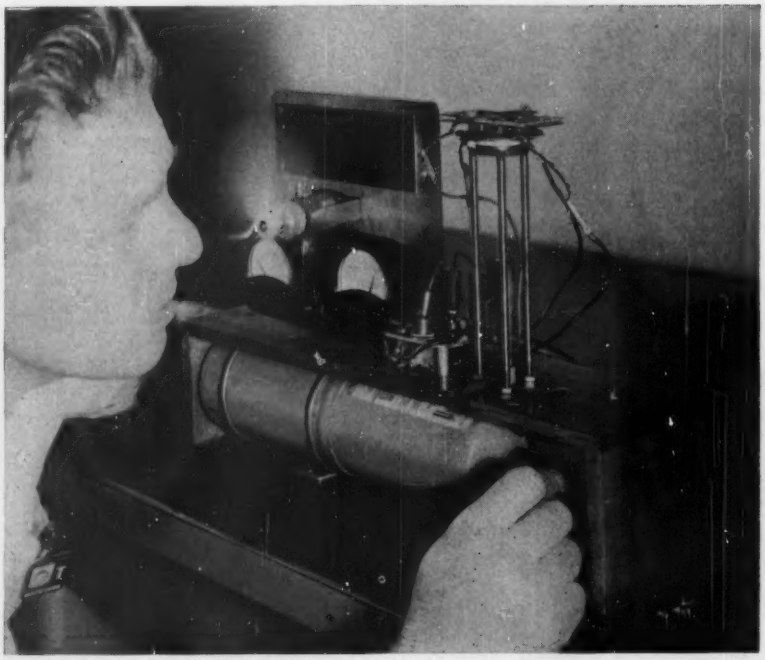
Developed by General Electric's Power Tube Dept., the experimental device provides optimum conditions for each stage: Thermionic conversion is most efficient at higher temperatures; thermoelectric generators work best at relatively low temperatures. In the GE combination, a production-type vacuum thermionic converter is sandwiched with a zinc-antimonide constantan thermoelectric generator.

When operating at a cathode temperature of 875 C (well below design temperature), the thermionic converter produces 0.2 watt. When its exhaust heat activates the thermoelectric unit (350-C hot junction, 100-C heat sink), over-all power output increases to 0.54 watt.

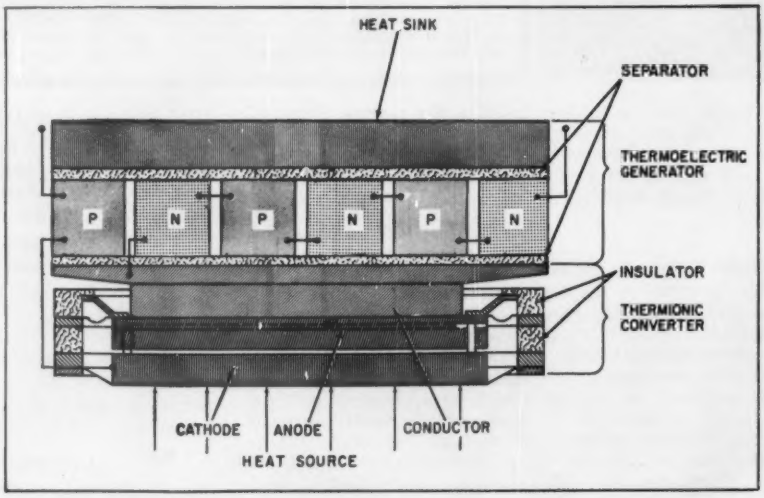
When the thermionic cathode is boosted to 1150 C (design temperature), the thermionic converter produces a minimum of one watt at about 2.5 per cent efficiency. With a cascaded thermoelectric generator, the power output of the combination would be about 2 watts and efficiency about 6 per cent.

Early studies indicate efficiencies of 16 per cent or more may be attainable with vapor thermionic converters operating at 1325 C. These converters would be cascaded with lead telluride thermoelectric generators (hot junction at 650 C, sink at about 75). Such temperatures would be available with solar, nuclear, or chemical heat sources.

After further development, the cascaded generator is expected to find uses in ships, submarines, and other fields where low-temperature sinks are easy to obtain.



Perched atop the tripod (at right), General Electric's cascaded converter produces twice as much power from a given amount of heat as either a thermionic or thermoelectric generator operated alone. Power from the thermionic unit (bottom of sandwich) runs the propeller; power from the thermoelectric generator is indicated by the instrument.



Cross-sectional drawing shows important parts of the two-stage energy converter. The device, which can be held in the palm of a hand, now operates with twice the efficiency of either a thermionic converter or a thermoelectric generator, may eventually exceed 16 per cent. According to GE engineers, the thermionic-thermoelectric combination may make the "exotic" generators feasible for large-scale power production.

WELDED STEEL PRESSURE TUBING

UNIFORMLY ROUND, DEPENDABLY SOUND—readily shaped and assembled

For every designer, the many thousands of miles of welded steel tubing in boilers, heat exchangers, evaporators and condensers throughout America prove these facts: welded steel tubing has dependable strength (*what pressures do you need?*) . . . it is easily formed (*are special shapes your problem?*) . . . it is accurately concentric (*will you use more drilled holes than a steam drum?*) . . . and has no hidden interior imperfections (*the rolled steel from which welded tubing is made is sound and smooth*).

These are reassuring facts to count on, whatever your product where tubing is used. They mean easier fabrication at lower cost, together with complete dependability in performance on the job.

Great design freedom is provided by the wide range of carbon and stainless grades at your command in welded steel tubing. Write for data-filled Bulletin 8591—and for immediate information on your current requirements, call a quality welded tube producer. LC-603

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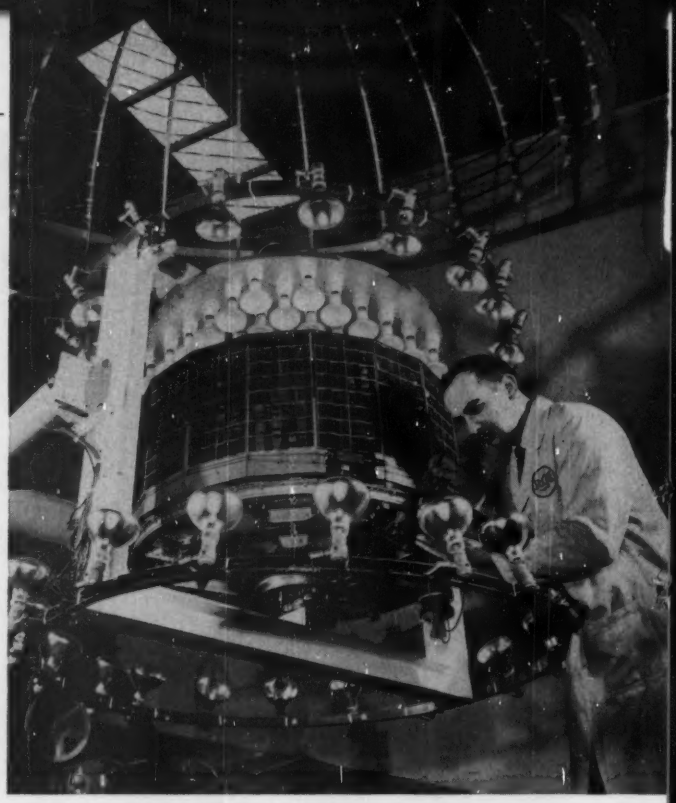
Pre-flight for Tiros II

Strapped-down gyros and a controllable magnetic field guided NASA's second weather satellite into a near-perfect orbit and positioned it for clear picture-taking. Here's how the builders ground checked this complex gear.

TIROS II, America's latest weather-eye-in-space satellite relies for guidance on control systems that weren't even on the drawing boards when the first Sputnik was launched. Three tiny gyroscopes (each weighs 14 oz) piloted the huge Delta vehicle that carried the satellite to its station; now that it's in orbit, a built-in magnetic field lets ground observers tilt Tiros to the best picture-taking angle.

The three gyros, able to measure motion 3000 times slower than the hour hand of a watch, were designed to sense even the slightest deviation in the Delta trajectory. Developed by Minneapolis-Honeywell Regulator Co., the gyros were fastened directly to the vehicle frame, rather than mounted on a complex gimballed platform. According to MH spokesmen, the "strapped-down" mounting is possible because of engineering advances which cause the new gyros to react to a minute change in vehicle attitude. Advantages of the mounting include lighter weight, lower cost components, and greater instrument payloads.

The camera-aiming system works against the earth's magnetic field, rather than activating special propulsion devices, rocket motors, or compressed-gas jets. A controllable magnetic field is generated around the satellite itself. When this field is made to interact with the earth's field, ground observers can tilt the craft to any desired attitude. The technique, developed by Radio Corp. of America, resulted from analysis of unpredicted shift in attitude of the first Tiros satellite.

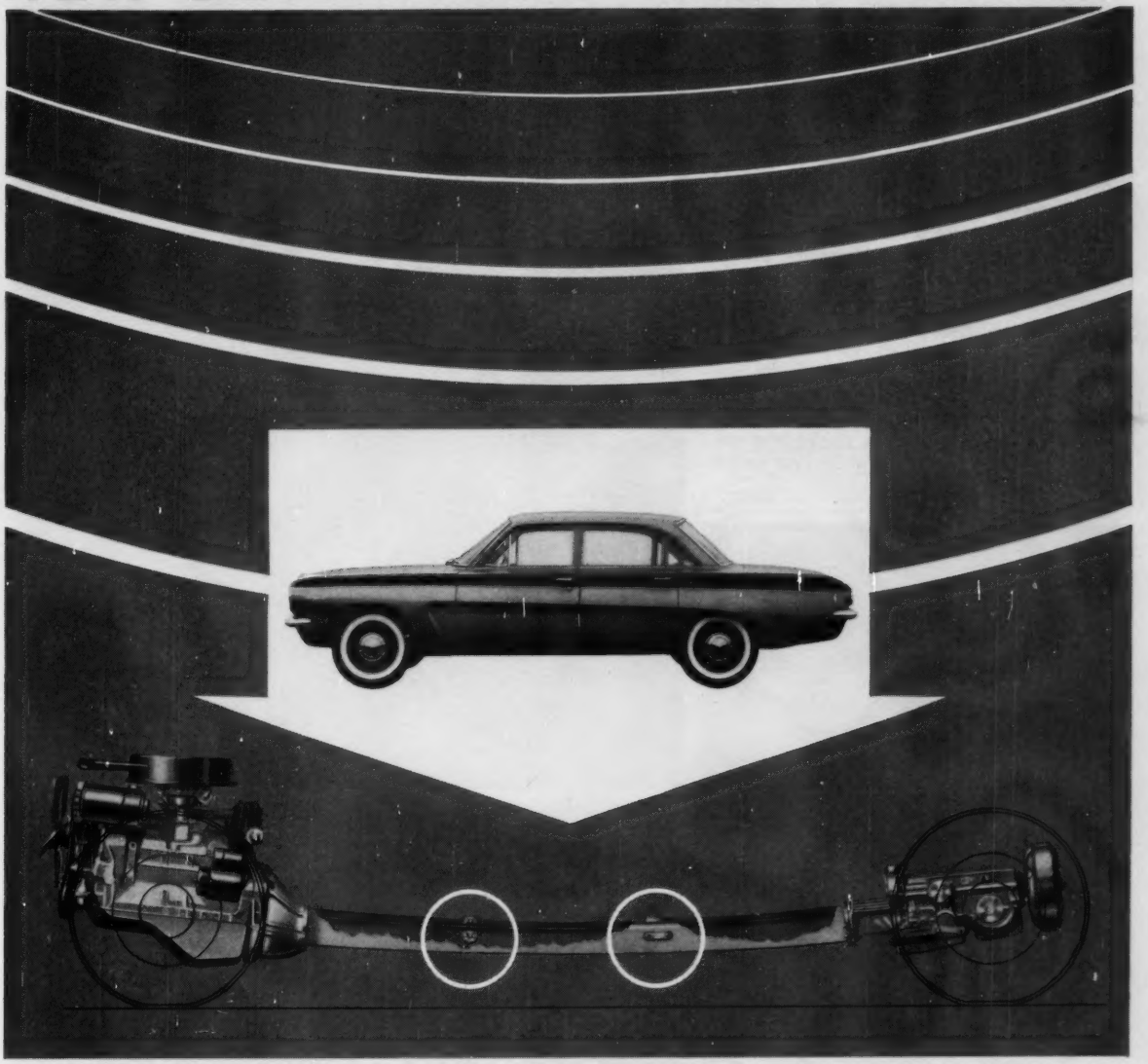


Ground observers tilt Tiros II to the best picture-taking attitude by activating its magnetic field. Forces set up by the interaction of this field with that of the earth counteract the unexpected gradual shift that was experienced with Tiros I.

In developing the novel control technique, RCA engineers set up a large spherical test cage in which the satellite was rotated. Within the cage, they created a magnetic field and a solar environment that were very similar to what the vehicle would encounter when in orbit. Lights above and around the craft were used to test performance of the solar cells designed to provide power in space.

Three tiny gyros mounted in this electronic package guided Tiros II into orbit. Able to sense extremely small deviations from the planned trajectory, the package relayed information to the ground, enabled observers to make corrections on the Delta-vehicle course.

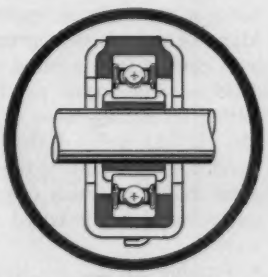
NEW DEPARTURE CASE HISTORY



NEW DEPARTURE BALL BEARINGS ARE USED IN TEMPEST'S REVOLUTIONARY NEW DRIVESHAFT!

N/D Sales Engineers cooperated with Pontiac engineers in the development of specially designed ball bearing assemblies to support the 2-inch "bend" in the Tempest driveshaft. These unique assemblies are rubber insulated to dampen driveshaft vibrations . . . and feature N/D sealed and lubricated-for-life Sentri-Seal ball bearings. Press-fitted with the bearings are plastic lined steel shells for snug support of this propeller shaft assembly—proved in over three million miles of rugged testing.

New Departure continues to help lead the way in advanced engineering for more reliable products in every line of industry and defense. For consultation or early design discussions on your ball bearing application, contact the N/D Sales Engineer nearest you, or call or write to New Departure, Division of General Motors Corporation, Bristol, Connecticut.



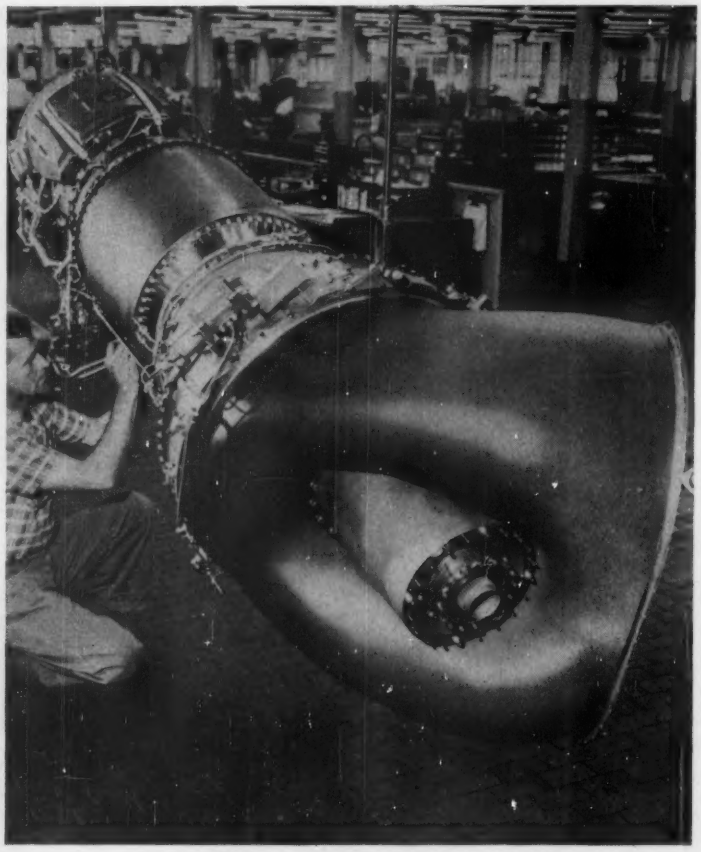
Two N/D ball bearing assemblies like this are mounted within "bent" torque tube.

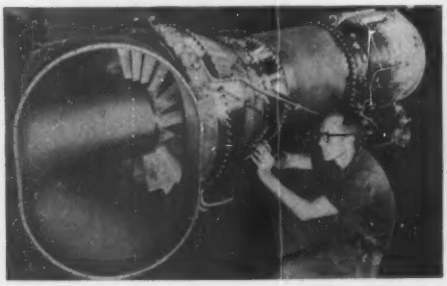
NEW DEPARTURE

BALL BEARINGS · PROVED RELIABILITY YOU CAN BUILD AROUND

Free Turbine for a Skycrane

JFTD-12, the new gas-turbine engine chosen to power Sikorsky's S-64 Skycrane helicopter, provides a maximum of 4050 shaft horsepower. Now under development at Pratt & Whitney Aircraft Div., United Aircraft Corp., the versatile new engine will have ground and marine capabilities as well. Since it features a free-turbine drive (which extracts energy from the exhaust gases of the jet to provide power), the engine can provide high torques over a wide range of output-shaft speeds. An industrial model, called the FT-12, develops up to 3000 hp, weighs 1150 lb (280 lb more than the helicopter engine). Prospective applications for the industrial version include primary and boost power for ships, high-pressure pumps and compressors, electric-power generation, and propulsion for large ground vehicles.





How to Handle Engineers

NEW YORK—A lively debate at the winter ASME meeting explored engineer-manager relations and how they can be improved. Speakers differed on both the theory and the practice of handling people, but most agreed on the growing importance of automation and computers in efficient management.

Management is a long way from being a true science, experts admit. Many of today's management problems can be laid to blind use of individual and social psychology in setting up management science, says Mr. L. Urwick, Urwick House, London. Problems with engineers seem to fall into this category, and two speakers summarized them this way:

• Trouble in the research department, according to Harold K. Work, director, Engineering Foundation of United Engineering Trustees, comes in measuring results of research. Direct benefits from a particular project may not appear until many years after it is completed.

"In view of the scarcity of good research personnel," Mr. Work continued, "considerable attention is paid to creating a favorable research environment. This involves everything from providing adequate motivation and fostering a co-operative attitude down to details of working and living conditions.

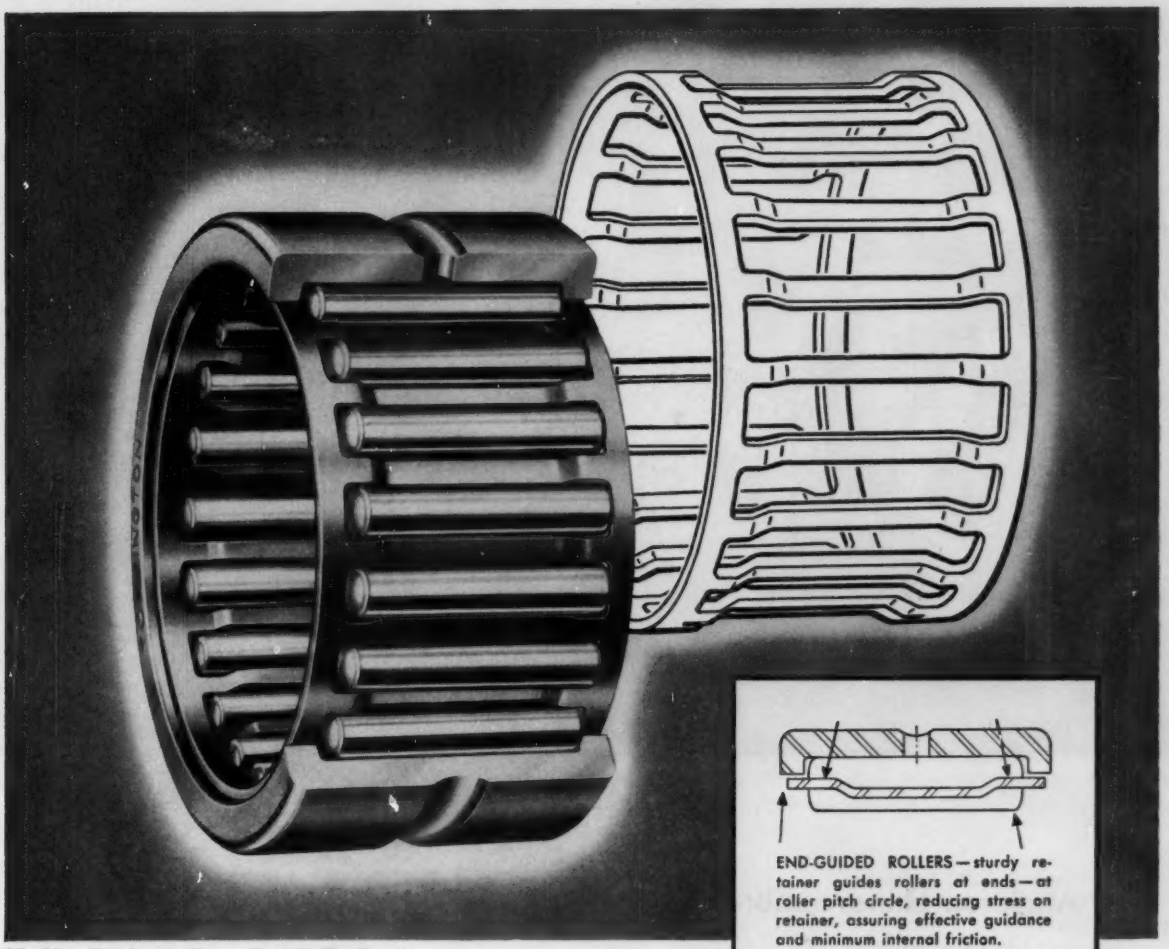
• Another major problem, reported C. E. Paules, vice president (retired) Esso Research and Engineering, involves "encouraging an adequate number of outstanding technical men to remain in nonsupervisory work and develop into true experts in particular technical fields.

"Unfortunately, management (at first) gave increasing public recognition to supervisory appointments . . . As a result, many excellent men, thoroughly interested in technical work, requested supervisory assignments solely in order to receive recognition. The assurance that they were being paid equally to their management counterparts . . . was not enough.

Engineers Joint Council Names Landis New Prexy

NEW YORK—James N. Landis, vice president, Bechtel Corp., is the new president of Engineers Joint Council. A past president and present council member of ASME, Landis succeeds Augustus B. Kinzel, vice president of Union Carbide, who headed EJC for the last year.

Landis' engineering career has been mainly in the power field. After a short stint as a mathematics instructor at the University of Michigan—where he received a BS Degree in Mechanical Engineering in 1922—he joined the Brooklyn Edison Co. where he remained until 1936. He was with Consolidated Edison from 1936 to 1948, serving as head of contract control and inspection and assistant mechanical engineer. Joining Bechtel in 1948 as chief power engineer in charge of engineering design and layout of steam-power plants, he became vice president in 1953.



The New *Torrington Heavy Duty Roller Bearing*

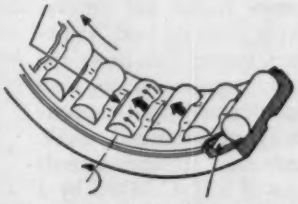
Key to Long Life... Roller Guidance Where It Counts!

This sturdy flange-riding retainer in Torrington Heavy Duty Roller Bearings insures the highest degree of roller guidance where it's most effective... at the roller ends along the pitch circle. You get outstanding service life through minimum internal friction, high roller stability and efficient lubrication.

Controlled contour rollers prevent high end-stress concentrations. Careful heat treatment of the channel-shaped outer race insures high shock resistance. The Heavy Duty Roller Bearing has proved successful under unusual conditions of deflection or misalignment. Torrington Heavy Duty Roller Bearings are giving longer life in such difficult applications as two-cycle engines, hydraulic pumps, oil-field equipment, sheaves and transmissions. For design and application assistance on the Heavy Duty Roller Bearing—and every basic type of anti-friction bearing—call your Torrington District Engineer.

END-GUIDED ROLLERS—sturdy retainer guides rollers at ends—at roller pitch circle, reducing stress on retainer, assuring effective guidance and minimum internal friction.

UNIFORM LOADING—Torrington controlled contour rollers eliminate stress concentration at roller ends. End-stress pattern of unrelieved cylindrical rollers is shown in black outline. Area in gray shows uniform loading over entire contact length of Torrington rollers.



AMPLE LUBRICANT STORAGE AREA is provided by the retainer design, which also allows unrestricted flow of lubricant within the bearing.

progress through precision **TORRINGTON BEARINGS**

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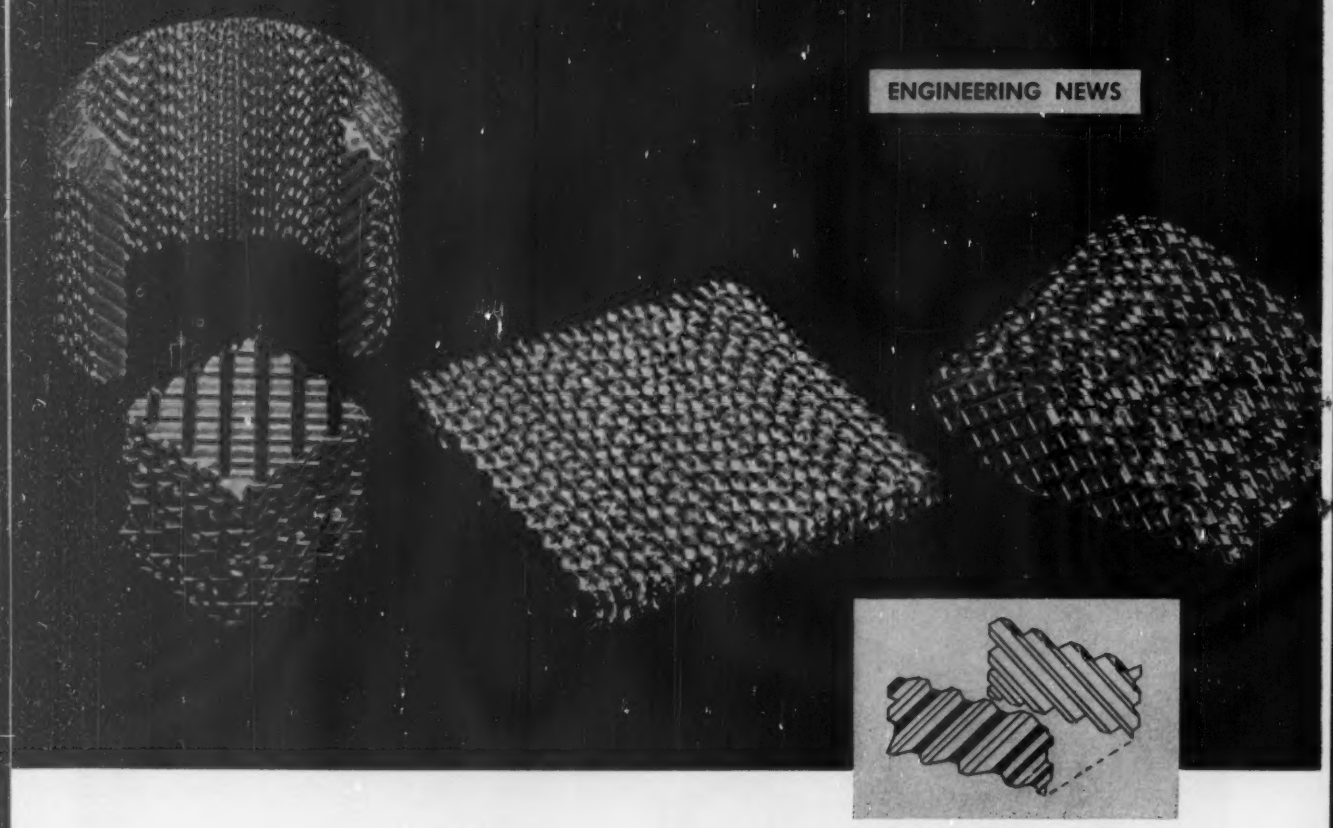


New Angle on Honeycomb: *Cross-Laminated Cores*

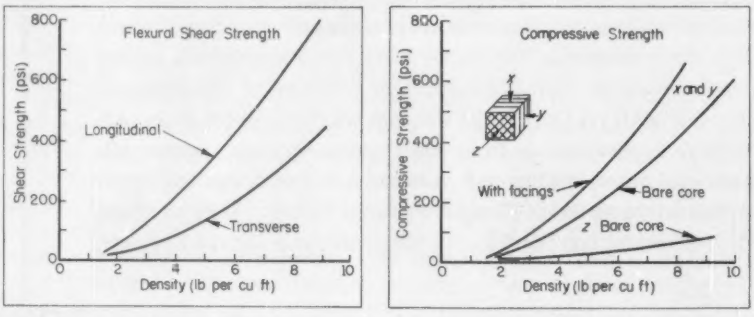
EDGEWOOD, MD.—A cross-laminated aluminum-foil core with "no weak planes" promises to expand design application of sandwich panels. The new core, called Trussgrid, combines the advantages of ordinary honeycomb with the volume stability of foamed aluminum, according to the developer, General Grid Corp.

Performance claims are impressive: Under a crushing load, Trussgrid exhibits twenty-five times the strength of regular honeycomb (equal densities and load perpendicular to honeycomb-cell axis). Core-delamination strength exceeds requirements of MIL-C-7438C by a factor of 10 to 20; shear strengths in longitudinal and transverse directions are also higher than the specification.

Because corrugations of foil layers cross at 90-degree angles, Trussgrid forms a naturally vented panel. This suits it for use in boundary-layer control applications, for internal fuel storage, and opens new potentials in the design of cooled or heated sandwich structures. Venting also allows bonding with all types of adhesives without danger of separation by curing-cycle gas pressures.

According to General Grid, the new material has superior machining characteristics. Since it has considerable strength in all three planes, it can easily be cut to size and shape without reinforcement with ice, wax, or resins. It can be roll formed to curvature and does not exhibit the anti-elastic behavior of conventional honeycomb.

While evaluation of Trussgrid properties is still in progress, pre-



Strength of the Trussgrid core in x and y directions (plot, right) permit application of high bonding pressures during mounting of edges and inserts.

liminary tests show the following comparison with regular type 5052 alloy honeycomb:

- Density (lb per cu ft) closely approximates that of honeycomb for equal foil thickness and cell size twice the corrugation height.
- Under edgewise compression of a core slice, Trussgrid is 10 to 30 times as strong as regular hexagonal core.
- Isotropic characteristics permit use where loads cannot be held parallel to cell axes of honeycomb.

Currently available in aluminum, the core can be made of any sheet material. Standard ½ in. thick sheets measure 96 to 98 in. long, 12 to 12.5 in. wide. Densities run from 4.5 to 8.1 lb per cu ft, depending on foil thickness and corrugation height.

Pay Continues Upward Trend For Engineering Teachers

NEW YORK—Average professional income of engineering teachers has increased by 14.7 per cent in the past two years, according to a report by the Engineering Manpower Commission of Engineers Joint Council. The survey covers more than 5000 engineering teachers, or more than half the nation's total.

Teaching salary accounts for 77.5 per cent of the average teacher's income, the remainder being derived from outside professional work such as consulting and research. Since the survey was first made in 1956, average basic teaching salaries have risen 31.1 per cent, while income from "outside sources" has risen 11.3 per cent.

In actual dollars, today's average salary for engineering teachers in American colleges is $8534. It is supplemented by an average of $2479 from outside professional income.

Other statistics compiled by EJC show that salaries increase with age, academic rank, and type of degree; the median teaching salary for instructors is $5380, and that for full professors averages $10,500.

The report is part of a more comprehensive survey of professional income for all engineers, scheduled for publication by the Commission later this year.

DRAFTING TRENDS

In a typical application of the POST Diazo Materials Selector Chart, a draftsman, supervisor and reproduction specialist solve a special print-making problem in short order.

Solve unusual reproduction problems with new Diazo Selector Chart

Keeping up with rapid developments in graphic reproduction and communication techniques is a difficult job these days, even for the experts.

From the engineer's and draftsman's point of view, it's largely a matter of sorting out the specific information which helps him do a better job.

The new POST Diazo Materials Selector Chart does just that—provides a condensed, tabular reference piece that helps you anticipate the ideal diazotype prints for various needs before they occur. This convenient chart gives brief information on sensitized papers, intermediates and specialties in terse "what, when, why and where" style.

If you're concerned, for instance, with print distribution to different departments, units or groups, then prints on a variety of colored stocks might be the answer.

Increasing print production from diazo equipment with a lower-power light source . . . making legible prints from worn old tracings . . . even making copies from an opaque print . . . all can be handled by use of new POST 206M-14, a fast, extra-sensitive whiteprint paper.

Suppose a design conference calls for a poster, actual size, made from a large engineering drawing, rigid enough for display, tough enough for extreme handling and on-the-spot sketches? POST diazo-sensitized cardstock in 32 or 50 lb. weight can turn the trick on standard reproduction equipment, ammonia process or semi-moist. For many more helpful solutions to similar situations, ask for your personal file-size copy, of the POST Selector Chart, available from your POST dealer or Frederick Post Company, 3652 North Avondale Avenue, Chicago 18, Illinois.

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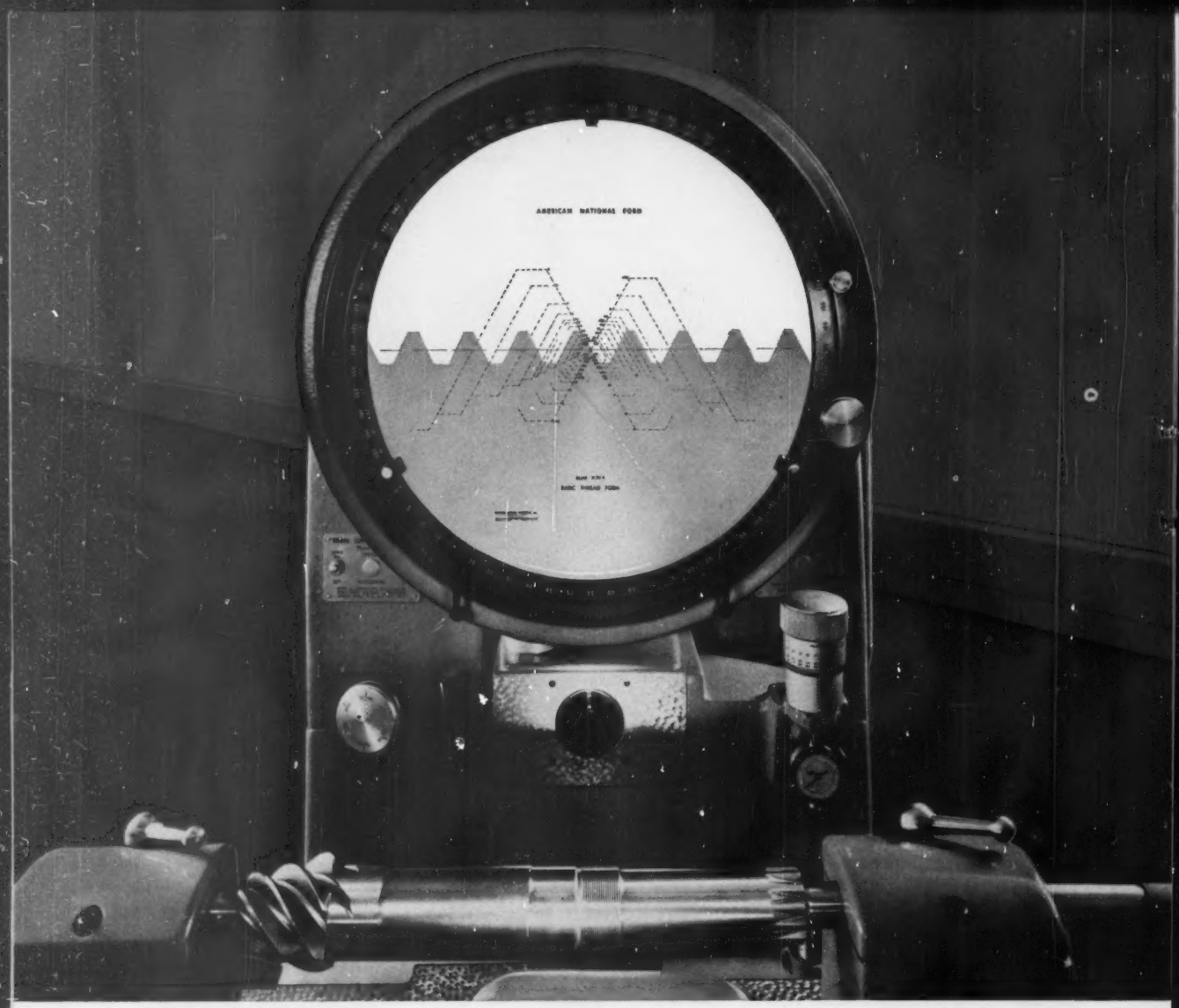

BETTER GEARS by making mountains out of molehills

This optical comparator is doing just that. The threads on the pinion in the foreground are magnified 31.25 times on the calibrated screen for intensely accurate inspection.

This is one of many details of gear manufacture and inspection that have won Double Diamond gears their reputation as gears thorougly qualified for high level performance in any application for which you buy them.

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403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
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418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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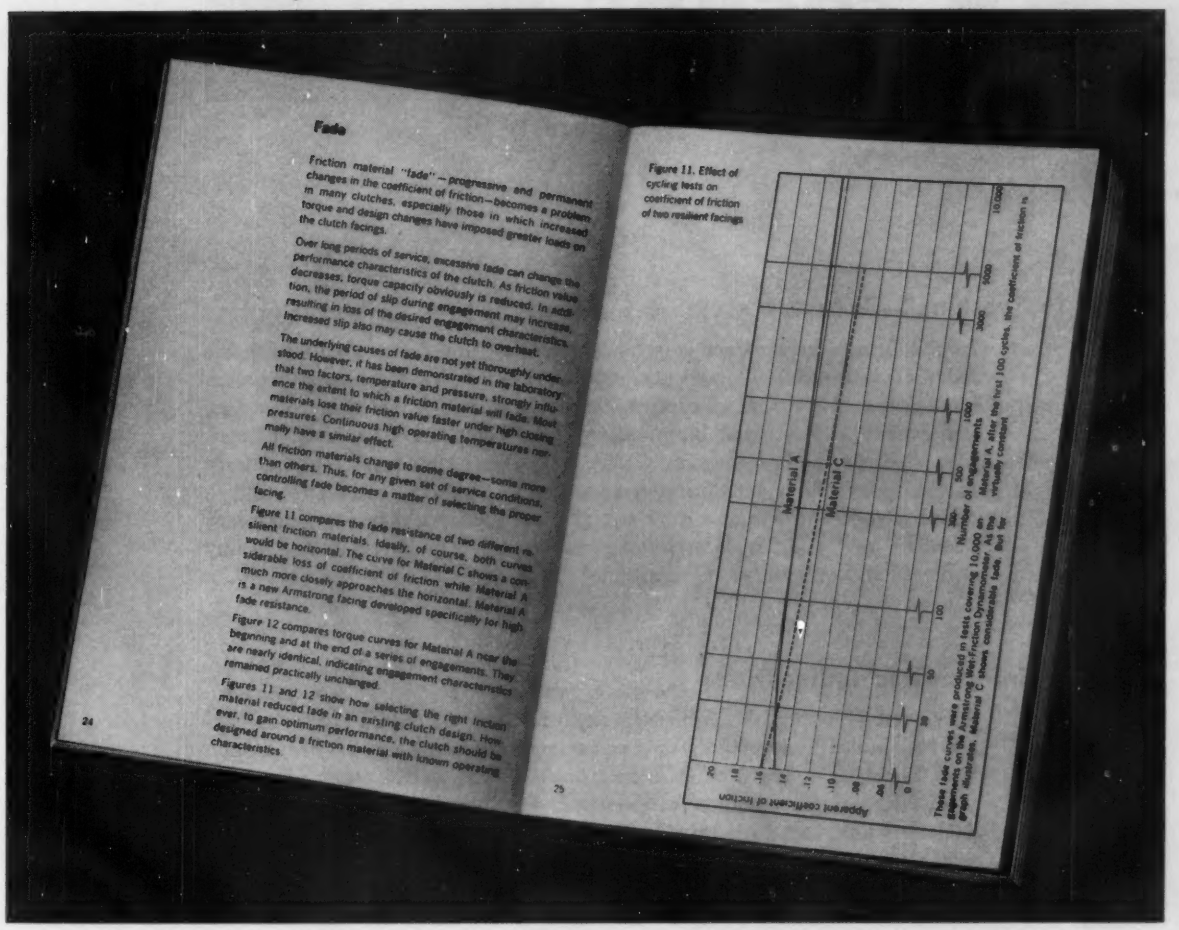
Fade
Friction material "fade" — progressive and permanent changes in the coefficient of friction — becomes a problem in many clutches, especially those in which increased torque and design changes have imposed greater loads on the clutch facings.
Over long periods of service, excessive fade can change the performance characteristics of the clutch. As friction value decreases, torque capacity obviously is reduced. In addition, the period of slip during engagement may increase, resulting in loss of the desired engagement characteristics. Increased slip also may cause the clutch to overheat.
The underlying causes of fade are not yet thoroughly understood. However, it has been demonstrated in the laboratory that two factors, temperature and pressure, strongly influence the extent to which a friction material will fade. Most materials lose their friction value faster under high closing pressures. Continuous high operating temperatures normally have a similar effect.
All friction materials change to some degree—some more than others. Thus, for any given set of service conditions, controlling fade becomes a matter of selecting the proper facing.
Figure 11 compares the fade resistance of two different resilient friction materials. Ideally, of course, both curves would be horizontal. The curve for Material C shows a considerable loss of coefficient of friction while Material A much more closely approaches the horizontal. Material A is a new Armstrong facing developed specifically for high fade resistance.
Figure 12 compares torque curves for Material A near the beginning and at the end of a series of engagements. They are nearly identical, indicating engagement characteristics remained practically unchanged.
Figures 11 and 12 show how selecting the right friction material reduced fade in an existing clutch design. However, to gain optimum performance, the clutch should be designed around a friction material with known operating characteristics.
24
25
Figure 11. Effect of cycling tests on coefficient of friction of two resilient facings
Material A
Material C
Number of engagements
Apparent coefficient of friction
These fade curves were produced in tests covering 10,000 engagements on the Armstrong Wet-Friction Dynamometer. As the graph illustrates, Material C shows considerable fade. But for Material A, after the first 100 cycles, the coefficient of friction is virtually constant.

New Armstrong technical manual on resilient clutch facings

Here's a manual of technical data that will help you improve clutch design and performance. All the information in this 48-page booklet was developed through engineering studies conducted at the Armstrong Research and Development Center. Case histories describing how clutches were altered to improve performance or lengthen service life in specific applications are included. And there are detailed discussions of and technical data on:

- Coefficient of Friction
- Frictional Stability
- Engagement Pressure
- Operating Temperature
- Fade
- Facing Density
- Clutch Chatter
- Many other aspects of clutch design, performance, and facing materials

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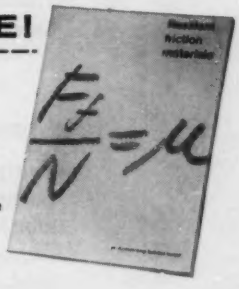

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"rushing"—industry style

In the future, help-wanted ads for engineering professionals will read like today's ads for college professors, says Prof. Frederick Harbison, Princeton University. Assurances of campus-like communities, stimulating colleagues, and sabbatical leaves will be forced by stiffer competition for creative scientists, engineers, and managers. Professor Harbison also notes that, contrary to Parkinson's Law, bureaucratic expansion or "empire building" is only a minor factor in growth of a work force. Administrators, managers, engineers, scientists, and other high-level functionairies are bound to multiply in any dynamic and progressive organization.

information indigestion

The flood of technical information that threatens to engulf engineers cannot be handled by computers, data-processing machinery, and the like, caution G. S. Simpson, Jr. and J. W. Murdock, Battelle Memorial Institute. The technique skirts the most important element in any information system—the user. All a machine can do is provide abstracts and copies of articles; the library searcher must still take on the horrendous task of eliminating out-of-date, inapplicable, and redundant information. Computer techniques would load the searcher with a "needle in the haystack" situation, hide significant information in the millions of articles he would have to digest. Engineers must find another way out of their too-much-information dilemma.

molten-metal simulator

Better castings should result from a Franklin Institute research project sponsored by the American Foundrymen's Society. Object of the study is to find out how heat flows from molten metals during casting. According to AFS officials, first step will be to evolve an accurate, efficient method of simulating dynamic behavior of flowing metals. Once techniques are developed, heat losses and temperature drops that occur during pouring can be predicted.

take-home notes

Thirty-two per cent of the companies replying to a recent American Management Association survey report they pay salaried professionals for overtime work. Straight time was the compensation most often used, but time-and-a-half and a two-rate system (time-and-a-half up to a certain salary level, straight time or less above that level) are also popular. Only one per cent of the returns mention an equal-time-off system, primarily because this arrangement does not relieve work loads. One fact clearly stood out in the data: Larger companies are more generous with overtime compensation.

sharp note on powdered metals

Newest application for powdered metals is in the cutting of other metals. A cutting tool developed by Ferro Powdered Metals Inc., Salem, Ind., does the job. Made of copper-infiltrated powdered iron, the tool boasts a life up to five times normal. Grain structure of the iron permits it to absorb vibrations which cause premature deterioration in conventional materials. The infiltrated copper conducts heat from the cutting edge, extending effective life even further.

PACE quickens at Northrop

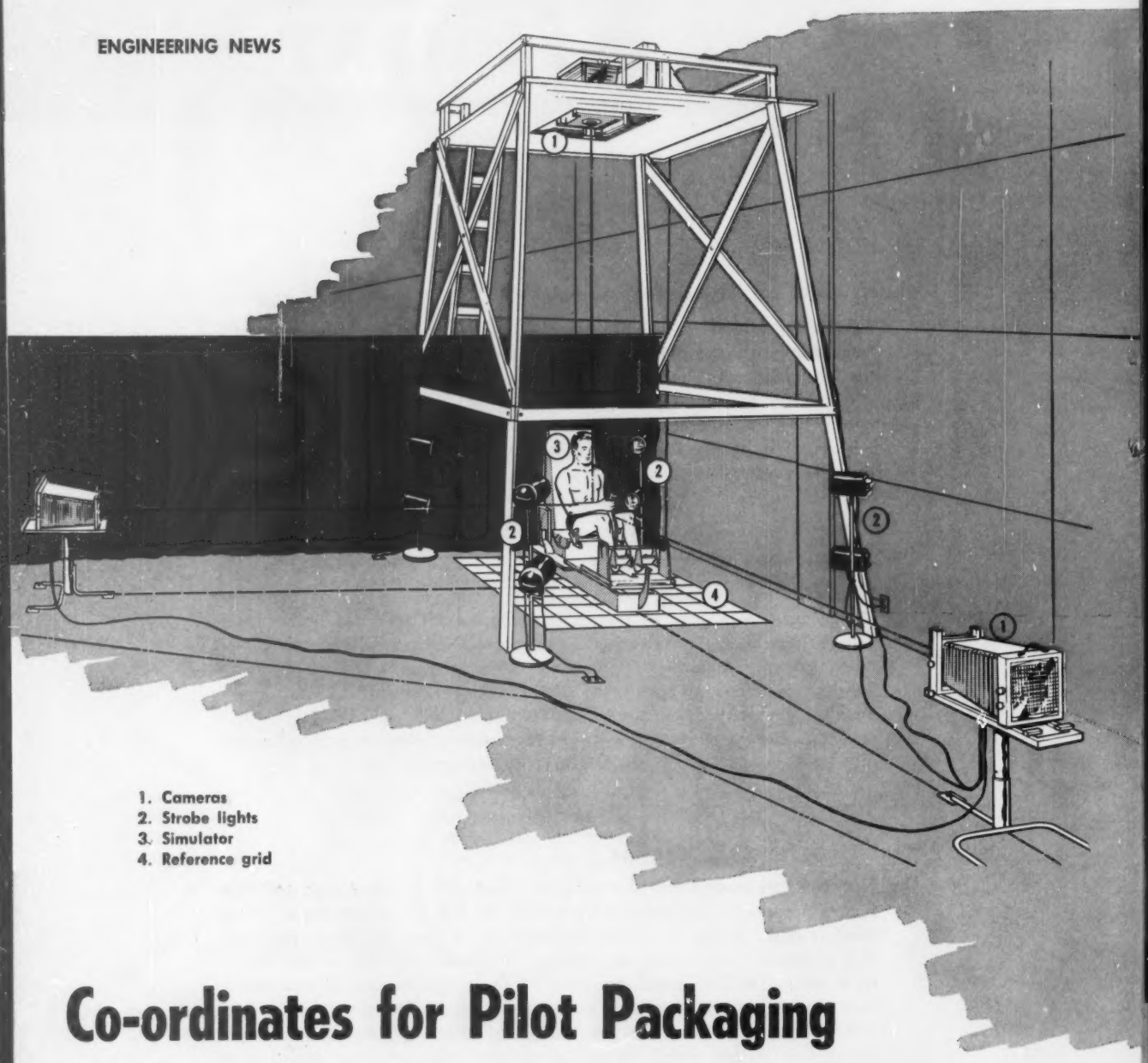
Industry could profitably spend as much money and effort on increasing management know-how as it does on technical research and development. This is from R. R. Nolan, general manager of Northrop's Norair Div., who notes that too few companies give serious consideration to "human research." Northrop is pioneering in this field with PACE (Performance and Cost Evaluation), a program of industrial measurement. PACE, which is essentially a statistical method of measuring group effectiveness, relies on group-effort ratings by observers, tips off problem areas to managers.

next step for the "exotics"

Now that unconventional power sources (fuel cells, thermoelectric and thermionic generators) are becoming practical, the Navy is sponsoring a "phase-two" research project at General Electric Co. Object will be to pin down best methods of controlling the devices. While development of the "exotic" dc supplies has been rapid, it's been relatively independent of advances in static conversion and regulation equipment. For the first time, GE scientists will attempt to design components for optimized power systems. Power generation and control techniques will be reviewed, compared, and analyzed; intrinsic characteristics of the generators and methods of handling output power will also be studied.

integrated specialists—key to materials progress

Backed with NASA funds, Rensselaer Polytechnic Institute will set up an interdisciplinary (physics, mechanical engineering, chemistry, etc.) materials-research program. According to RPI faculty members, the program will turn out large numbers of engineers who are qualified to develop materials which were considered "impossible" a few years ago. Many material problems are aggravated by effects of specialization among technical men. By attacking these specialization problems at the research level, the new approach will provide a technique that can't be duplicated by other methods.



1. Cameras
2. Strobe lights
3. Simulator
4. Reference grid

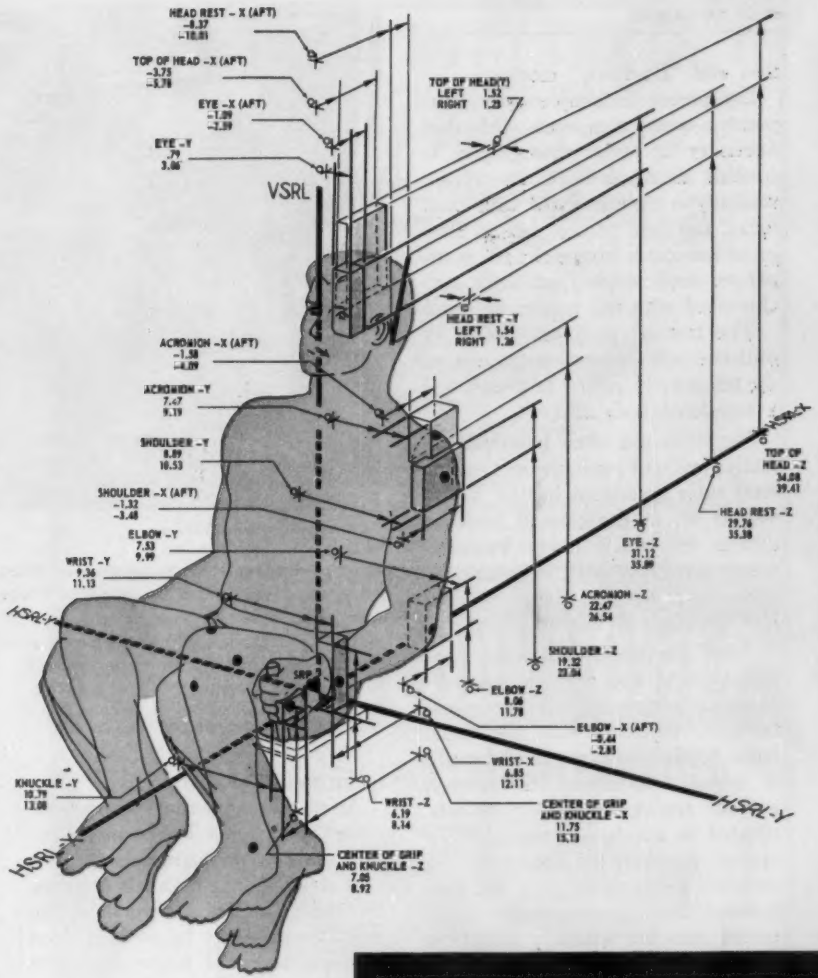
Co-ordinates for Pilot Packaging

J. W. CHAFFEE
Human Factors Laboratory
Convair (Fort Worth) Div., General Dynamics Corp.

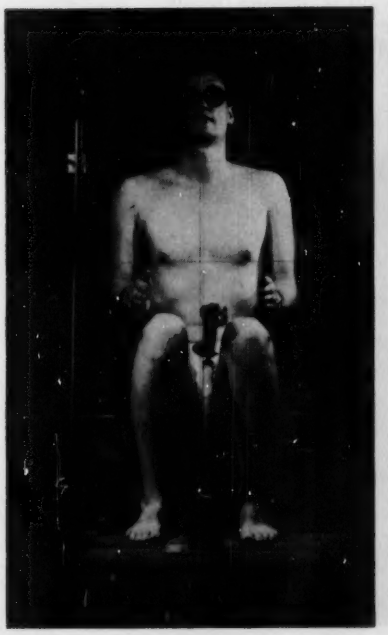
THE measure of a man—anthropometrically speaking—becomes critical design data when he is to be "packaged" for ejection from high-performance aircraft. Crew-station specialists strive to encapsulate a pilot with reasonable comfort, adequate work space, and hold him clear of fast-moving actuating mechanisms. Where speeds are supersonic, they must give him positive protection from the bear-trap action of closing shells.

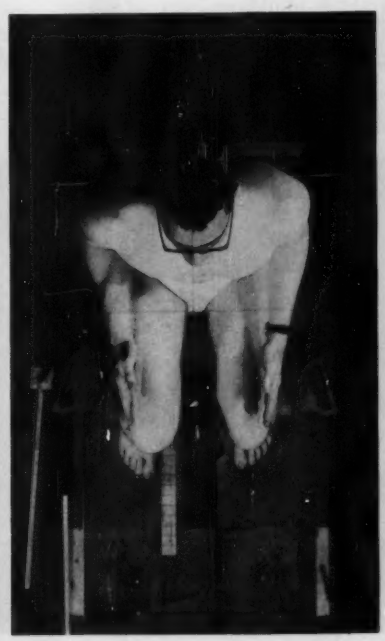
Convair human-factors engineers, laying down requirements for interior layout of the B-58 capsule, found no shortage of conventional anthropometric data. Unfortunately, such standardized dimensions—including body length, breadth, and diameter—described the military aviator in the traditional rigid posture, one completely unrepresentative of his position when he is "folded up" for ejection.

To fill the human-measurement gap, Convair specialists, borrowed and modified an aerial-mapping technique called *photogrammetry*. But instead of using simultaneously exposed negatives for drawing topographic contours, they analyzed top, side, and front photos for computing precise three-dimensional co-ordinates of a pilot's feet, knees, hips, shoulders, elbows, hands, and head. Posed in a capsule simulator, typical-size Air Force aviators were accurately dimensioned for both ejec-



Designing "elbow room" for flight crews poses a difficult workspace problem for human - factors specialists: Crewmen and capsules must stand ready for possible split-second ejection. Borrowing an aerial-mapping technique, Convair converts three-view pilot photos (below) to precise "spatial" portraits (right).





tion and "fly-down" modes.

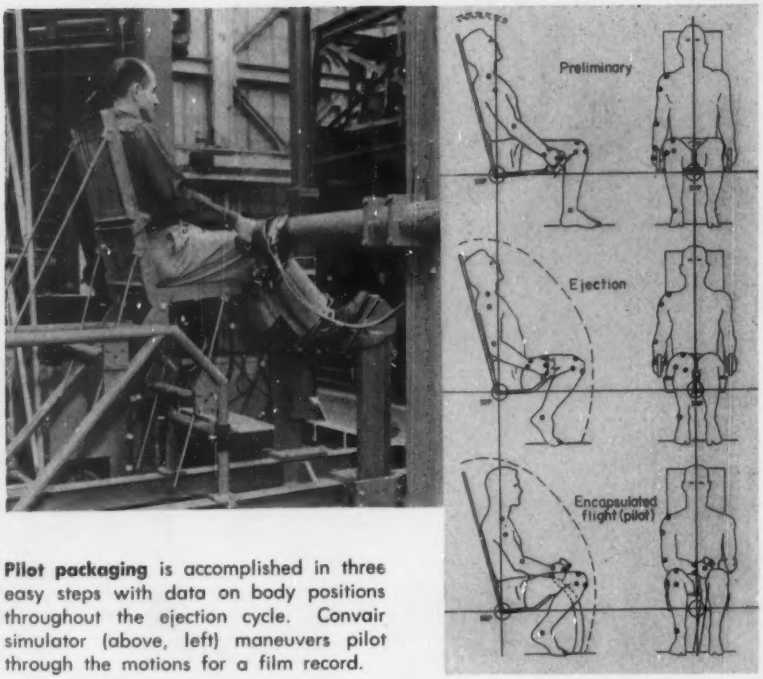
Equipment is simple and inexpensive when compared with that necessary for aerial photography. It consists of three 8 in. by 10 in. studio-type cameras, fitted with long-focus, flat-field process lenses. Illumination comes from eight 100 watt-per-sec stroboscopic flash units synchronized with the camera shutters.

The method produces sets of simultaneously exposed negatives of the test subject, reference marks, and a simulated body support.

Negatives are often measured directly without enlargement using steel rules graduated in 0.01 in. divisions or, in the case of involved studies in which many measurements are taken, with automatic devices such as the Benson-Lehner X-Y Oscillograph Reader ("Oscar").

From the negatives, direct analogs of x, y, and z spatial co-ordinates are obtained. All anatomical features, together with the usual body depths, breadths, and lengths of interest, are located in this way, and the analog dimensions are substituted in simple equations for the optical geometry of the recording system. From these, very accurate full-size readings are readily determined that are virtually free from parallax error.

When negatives are read on the Oscar, its output may be fed as direct input into high-speed electronic computers to give the transformed measurements. Alternatively, results may be accumulated for subsequent statistical analysis.



Pilot packaging is accomplished in three easy steps with data on body positions throughout the ejection cycle. Convair simulator (above, left) maneuvers pilot through the motions for a film record.

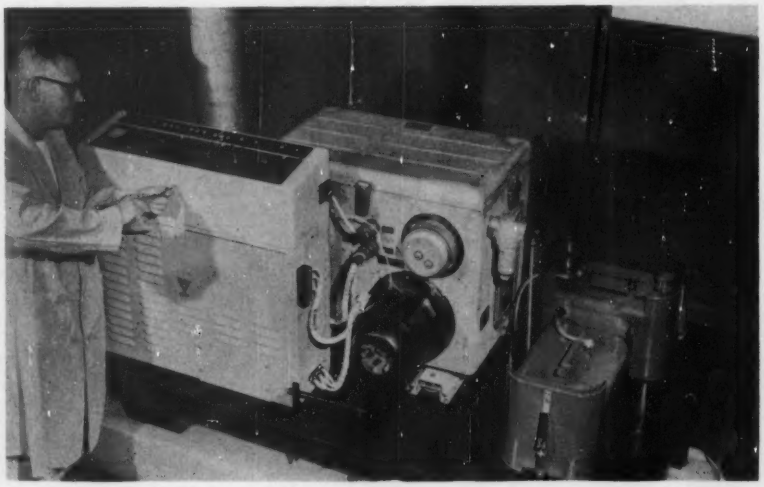
An obvious advantage of this technique—which has been called "anthropometric photogrammetry" — is that a permanent record is provided by the negatives. Several design studies may easily be performed on a single series of negatives. This effects considerable savings in data-gathering costs.

The technique was recently used to establish minimum internal space requirements for the B-58 escape capsule. Several positions of the body were studied representative of attitudes assumed by the pilot during emergency procedures and aircraft abandonment. Data describing body clearance and limb positions were obtained and treated statistically to establish design requirements.

In addition to measuring body size and workspace requirements, it is planned to use this technique in the investigation of the muscular output of human operators in relation to body size and, more particularly, body geometry.

Power for a Countdown

Self-sufficient auxiliary power units will be shipped to remote regions for work in Project Mercury. The gas-turbine-driven 30 kva alternators will feed power needed to check out electronic equipment aboard aircraft involved in the project. Built by Solar Aircraft Co., San Diego, Calif., the 50-hp power unit weighs 360 lb.



Atom-Blast Simulator Checks Electronic Components

Split-Second Gamma Burst Produced by High-Speed Electrons

CULVER CITY, CALIF.—Gamma radiation similar to that from an atomic bomb is being used to "flash test" missile electronic systems in the laboratory.

The radiation is being produced by a "linac" (linear accelerator) built for the Army by Hughes Aircraft Co. and now in operation at White Sands Missile Range, N. Mex. It is capable of producing a single, high-intensity pulse of about 10^7 volts for $\frac{1}{4}$ microsecond.

Compared to the nuclear reactor it imitates for a split-second of time, the linac is small—it occupies a few cabinets. Nothing visible occurs during its operation, except what appears on the instrument display panels.

The accelerator has three basic parts—two 5 million watt klystron tubes, and an electron gun. The klystron tubes inject microwave energy into the high vacuum of the 30-in. accelerator tube. Then electrons are fired which ride the waves, picking up speed as they travel. In this way the beam gains about 10 million volts in the $2\frac{1}{2}$ ft long accelerator tube. When the electrons exit, they strike a target of heavy metal such as tungsten. This bombardment generates a gamma radiation, similar to that from an atomic explosion, in which the missile components are tested.

Fired through lucite disc en route to tungsten target, electrons produce a "fracture line" effect.

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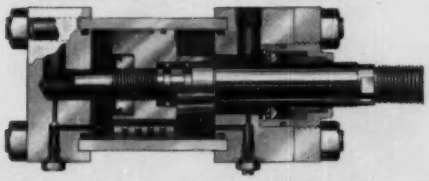

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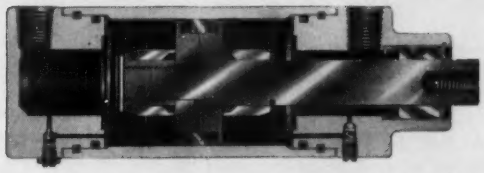

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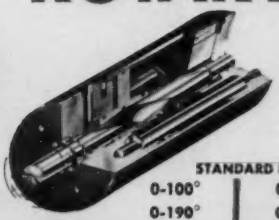

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Circle 414 on Page 19

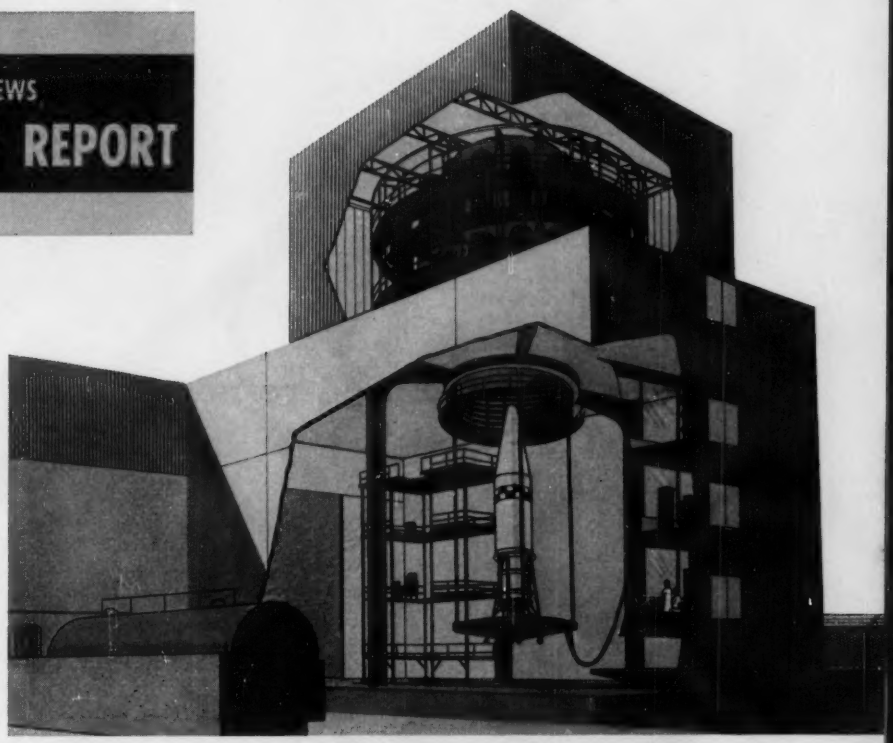
Four rotating legs enable the amphibious Go-Devil to roll over sizable obstacles. It can also climb 7-ft high banks, wade in shallow streams, and cruise in deep water. Chassis is in two pieces, with a hinge in the middle to allow turning. The vehicle is made by Wagner Tractor Co.; tires, by Goodyear.

Five-pound transistorized track-walker finds flaws in rails and reports them to the operator by means of an audible signal. Depth of the flaw is indicated by a meter in the handle of the instrument. The Audigage rail flaw detector is built by Branson Ultrasonic Corp.

First American sunroof is Studebaker's Lark Skytop. A sliding vinyl top is available on all 1961 sedan and hardtop models.

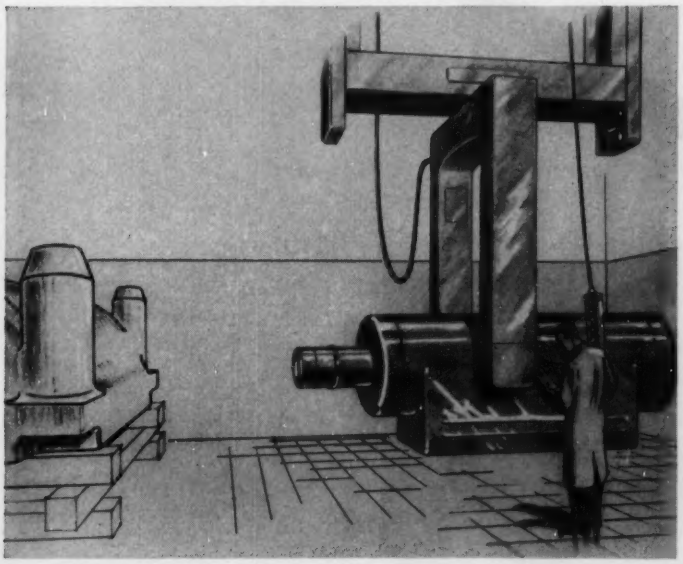
ENGINEERING NEWS

PICTURE REPORT



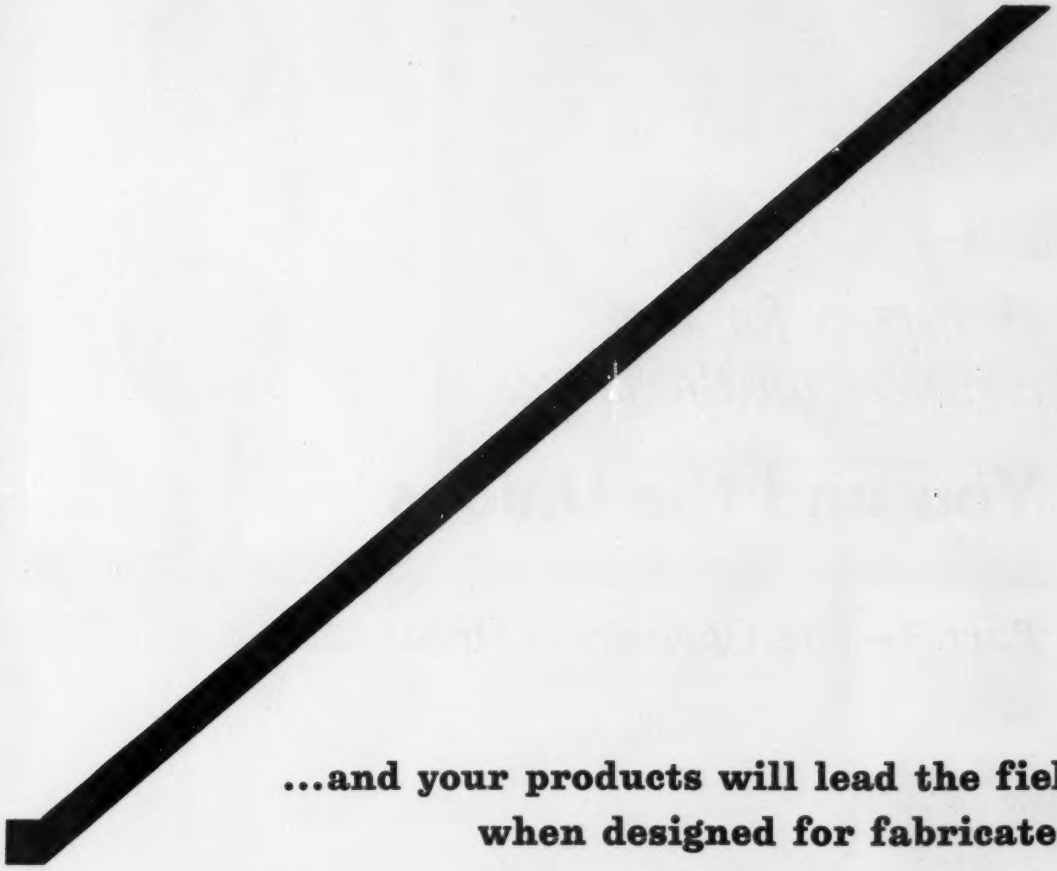
Extremes of heat and cold encountered by satellites and spacecraft will be duplicated in a simulator being built by Lockheed Missiles and Space Div. at Sunnyvale, Calif. Tests are to be conducted under "near-orbital" conditions. Quartz lamps will provide up to 1000 Btu of heat per sq ft per hour, and liquid nitrogen will cool the chamber to −320 F.

Clear x-rays of steel structures over a foot thick will be made in minutes with a powerful linear accelerator being built for A. O. Smith Corp. by High Voltage Engineering Corp. Linac produces x-rays by firing high-energy electrons in a straight line down an evacuated tube; radio waves accelerate the electrons to almost the speed of light. At the end of the tube, electrons strike a tungsten target, producing the x-rays at 6000 roentgens per minute.



Fiber glass goes to sea in the largest yacht of this material ever made. The Mercer 44, designed by naval architects Tripp & Campbell and built by Mercer Reinforced Plastic Corp., is 44 ft long and has an 11-ft, 9-in. beam. Hull, deck, deck cabin, cockpit, and centerboard housing are all molded of reinforced polyester. A bronze stock is molded in the rudder. Flush decks and the absence of framing makes the Mercer 44 more roomy than a comparable wooden boat.

Santa's red-nosed reindeer leads the way...



...and your products will lead the field when designed for fabricated steel!

THE leader's products in any field always stand out like a sore thumb (or red nose). That's because they perform better, require less maintenance, and save the customer money in the long run.

Fabricated steel, joined by welding, offers designer, manufacturer and user an outstanding combination of benefits:

Strength—steel is up to 4 times as strong as cast iron.

Rigidity—steel is up to 2½ times as rigid as cast iron.

Light Weight—with welded steel, just the right amount of metal is placed exactly where it is needed. No waste to buy and ship.

Impact Resistance—welded steel fabrications are unsurpassed in their ability to withstand abuse.

Ease of Modification—no patterns to change, no foundrys to wait for. Cut, bend, weld . . . to make any changes needed.

Modern Appearance—modern, streamlined products for today's competitive market result from proper designs for fabricated steel.

If you feel there are some areas of your company's manufacturing where you could gain a competitive advantage by switching to fabricated steel, call in your local LINCOLN Field Engineer. He won't design your product for you, but he can supply helpful time and cost-saving ideas when you are starting to change over.

THE LINCOLN ELECTRIC COMPANY
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LINCOLN WELDERS

Circle 415 on Page 19

SPEEA
WEA

A survey for the engineer on the fence:

You and the Unions

Part 3—The Opposition Organizes

SCPEA
APEP
CWEPE
EAA
ESG
EA
AFTE
IUE
FWISU

IT is no secret that managers and professional-engineering societies have joined forces to check union growth. They are doing everything in their power to convince the engineer that, as a professional, he should resolve differences with his employer without calling for union help.

These two groups have one major advantage: Most engineers are already on their side. But they have problems as well:

- Managers, even those working through associations, are often unable to unite in a common defense against unions.
- Professional societies, although better organized, are forced to limit their activities under penalty of lawsuit.

Restrictions on the Societies

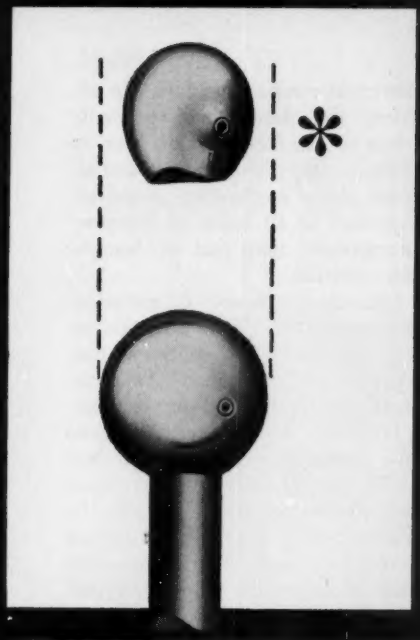
Professional societies find it difficult to directly oppose the unions because of legal and tax restrictions. The Taft-Hartley Act states:

> *Employers cannot interfere with, restrain, or coerce employees who wish to exercise their guaranteed right to organize, nor can employers dominate any labor organization or contribute financial support to it.*

Since many members of professional societies are also employers, active antiunionism by the societies is therefore limited. The act does not bar the societies from commenting on the union situation, nor does it restrain them from urging their members not to join unions. It simply prohibits direct intervention.

Of all the engineering societies, National Society of Professional Engineers most actively opposes unionism. NSPE is not as vulnerable as the others because it operates under a section of the Internal Revenue Code that applies to "business

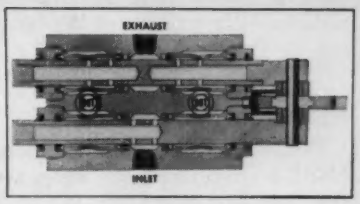
Circle 416 on Page 19→



after 17 years... replacement parts ***one handle ball!***

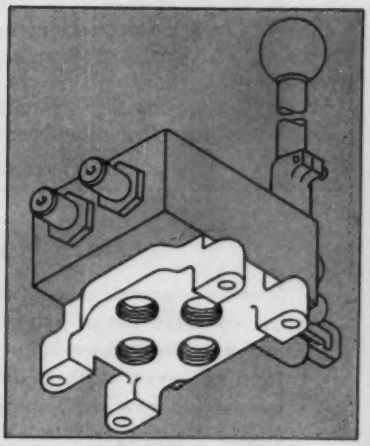
Human hands wore this metal handle ball to a fraction of its original size before the customer returned the valve to us for reconditioning. This high pressure hydraulic valve performed faithfully for nearly two decades with only such minor maintenance as replacement of "U" packing. We replaced the handle ball, repacked it, cleaned it up, and sent it back. This kind of trouble-free service is typical of Hunt hydraulic valves.

¾" MS-551-N4



The Higher the Pressure The Tighter the Seal

Cross-section view shows Hunt system of "U" packing as opposed to "metal to metal". "U" packing provides zero leakage on water hydraulic service.



Sub-Base Mounting Simplifies, Speeds Up Maintenance

New sub-base mounting is now available on all Hunt hydraulic valves. Easy, quick replacement for maintenance with no disconnecting of pipes.

HUNT HVC

HUNT VALVE COMPANY DIVISION OF IBEC SALEM, OHIO

Quick-As-Wink AIR & HYDRAULIC CONTROL VALVES

leagues, chambers of commerce, real-estate boards, and boards of trade not organized for profit." Societies belonging to Engineers Joint Council are classified with "religious, charitable, scientific, literary, and educational" groups. The section covering EJC members states that the qualifying group may not attempt to influence legislation, but NSPE is not hampered by this restriction.

If the societies were convicted of violating the T-H Act, they would lose the tax-free status they currently enjoy. This could be a serious blow to EJC; its offices are located in mid-town New York, a region where real-estate taxes are very high. NSPE, by way of contrast, is located in a much lower tax area—the outskirts of Washington, D. C.

NSPE's Solution

Favored with more freedom, NSPE is promoting a new weapon—the "sounding board."

A sounding board is essentially a nonbargaining organization composed of professional employees, or a mixture of professional and management representatives. It is generally organized to encourage free exchange of ideas between the managers and the managed. It is an internal-communication tool.

NSPE recommends that its state societies encourage sounding-board organizations to become active in local engineering-society chapters. By so doing, NSPE hopes to curtail the unions and, by strengthening its own position in local chapters, become better equipped to serve engineers at the local level.

The courts have never challenged NSPE because there is confusion as to whether sounding boards qualify as "labor organizations." Legal authorities disagree and there has never been a test case.

To clear up the uncertainties, law makers are studying several amendments to the Taft-Hartley Act. The difficulty lies in drafting language that will permit nonbargaining units to operate effectively without allowing company-dominated labor unions. One bill seems to pass both tests. It is supported by NSPE, but not by the other societies.

Sounding Board, GE Style

The type of sounding board that includes managers and supervisors as members evolved at General Electric Co. Formed in 1938-39, the General Electric Engineers Association attempts to act as a voice for the engineers, help them make better use of company facilities, promote more efficient engineering effort, and enhance the profession in other ways.

Officers of the Association claim it has resulted in a better exchange of ideas between management and professional people, and has demonstrated that engineers have a high interest in company welfare. In addition, the Association reportedly brings out the factors which promote efficient company operations and efficient use of engineering personnel. Engineers at all levels of company management take part in Association activities.

GE sounding boards do not negotiate or bargain. Their strength lies in a system of representation that provides a "pipeline to management" for every engineer-member.

Engineers with common interests and problems are divided up into small units of 20-50 people. Each unit elects a representative, and the representatives are, in turn, divided into groups with common interests. From these groups, *principal* representatives are chosen. Main operating body of the sounding board consists of all representatives; principal representatives and company officers form a steering committee that meets weekly.

The steering committee has very limited authority. Responsible to the larger group, it recommends how funds shall be spent and what changes should be made. Only the main operating body, however, can authorize changes.

Main channels of communication for the GE sounding boards are the publication *Integrator*, general meetings conducted by the Association, and special meetings conducted for small groups of employees.

Managers Aren't Members

Not all sounding-board organizations allow supervisory personnel to join. Some of these groups walk a very fine line between unionism and the "every-engineer-for-himself" doctrine. Like the unions, these types of sounding boards generally state their objectives as:

- To promote the general welfare of professional technical personnel.
- To enhance their professional standing.
- To foster closer understanding of their problems.

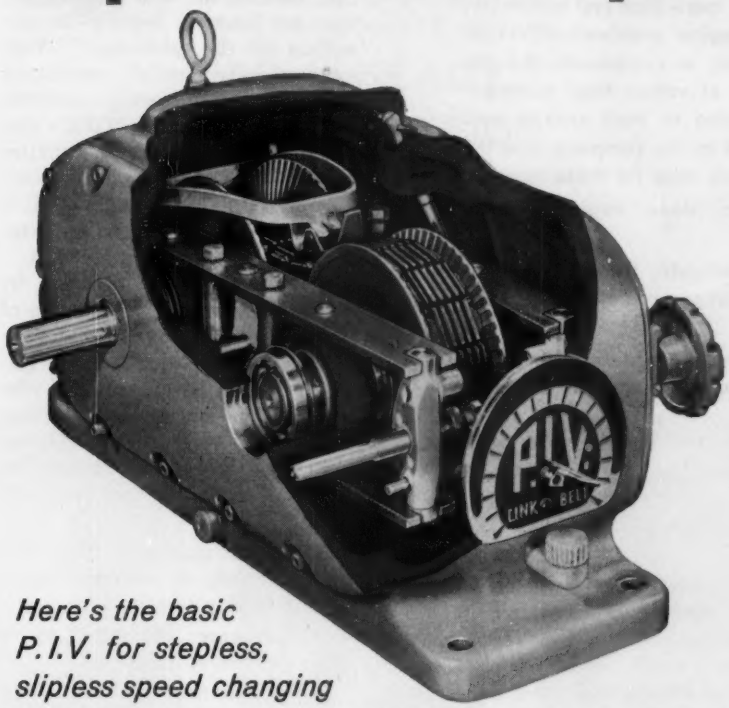
According to R. J. Wilkinson, president, Conference of Professional Technical Personnel at Bell Telephone Laboratories (a sounding board of the no manager-member type), sounding boards are more effective than unions in aiding the

Dark-Horse Solution

Sounding boards may never become popular; they may be legislated out of existence, killed by the unions, or neglected by management. But they may still fulfill an important function, even if they do die young. Informal sounding boards are now developing. Resulting from highly effective engineer-manager relations, these "relaxed" groups have already appeared at DuPont and Dow Chemical Co. In concept and in characteristics, formal and informal sounding boards are much the same. However, the informal sounding board has no rigidly defined organization, no charter, and no formally elected officers. Fostered by management, this offspring contains no aspects of unionism. Because the unions can't claim unfair labor practices, informal sounding boards may become more acceptable to management.

LINK-BELT P.I.V. is available in all these ways for

super-sensitive quality control



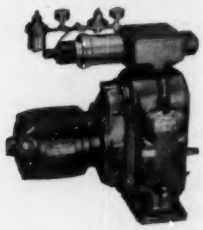
Here's the basic P.I.V. for stepless, slipless speed changing

Today a growing number of production machines and operations demand extremely accurate transmission of power with variable speed control. For these requirements, Link-Belt P.I.V. is available in the many ways shown below—with automatic controls and integral differential to satisfy an infinite number of variable speed applications.

Variable from top speed to minimum speed with no steps, no stops in between, Link-Belt P.I.V. is industry's only chain-driven variable speed drive. Teeth—not tension—permit positive, high-efficiency power transmission.

For information on the full P.I.V. line, call your nearest Link-Belt office. Or write for Book 2274 on basic P.I.V., and Book 2774 explaining P.I.V. with integral differential.

Link-Belt P.I.V. is available in 8 sizes and 16 standard types, in capacities from ½ to 25 hp—for horizontal or vertical mounting. Compact design simplifies installation as a separate unit or a built-in part of a machine. P.I.V. is totally enclosed, automatically lubricated.



PNEUMATIC (shown) — The P.I.V. pneumatic ratio changer is used as a final control element providing fully automatic control of speed. Operates from standard pneumatic controller in systems regulating pressure, temperature, rate of flow, etc.

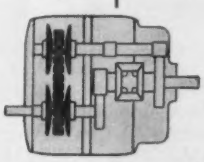
MECHANICAL — Predetermined timing, cyclic, or characterized regulation can be accomplished by P.I.V. with mechanical controls.

HYDRAULIC (shown) — Consists of a low-pressure hydraulic Servo system with a precision valve positioner. Intended to give automatic speed control by direct operation with any form of linkage. A minimum operating force is required.

ELECTRONIC — Flexible form of speed control to provide either "on-off" or modulated speed response of P.I.V. drive. Electric control motors are available to match a wide variety of electrical control systems.

P.I.V. with integral differential gearing

CONDENSED SPEED RANGE TYPE of integral differential results in a ratio range less than a standard P.I.V. with the advantage of increased horsepower capacity, high ratio stability and accuracy. These drives are applicable wherever small ratio range is required but with extreme accuracy of ratio control.



EXTENDED SPEED RANGE TYPE of integral differential results in infinite ratio range and output speeds down to zero with a constant input speed. Clockwise and counterclockwise rotation through zero is also obtainable. These drives may be used whenever a ratio range greater than 6 to 1 is required.

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LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,188

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It's Not the Money

Why do engineers join unions? Money, quips the cynic. He is only partly right. Managers are now beginning to realize that the engineer is concerned with more than just his salary; there are psychological and sociological problems still to be solved. Through training, inclination, or experience, the engineer has acquired different sets of values than management. Engineers tend to be devoted to their careers and work; managers are more oriented to the company and the job performed. Tensions and conflicts arise for these reasons:

- **Because they deal in technical ideas, engineers have definite status feelings.**
- **Believing themselves highly intelligent, they tend to assume personal responsibility for improving their own environment.**
- **Lacking power and control to make the desired improvements, engineers feel managers are a potential threat to development of their profession.**

Managers agree that solution of the engineering-union problem lies in easing these conflicts.

engineer if four principles are adhered to by both board representatives and management. Each group must:

- Listen understandingly to the other.
- Present "considered views," as contrasted to frivolous or irresponsible demands and opinions.
- Effect or appoint acceptable spokesmen—the engineer-spokesmen must truly represent the engineers, and the management-spokesmen must be adequately backed.
- Believe that the other group has good intentions and is interested in a fair settlement.

Opponents Have Their Say

The sounding-board approach is not fully acceptable to management. It may yet be ruled an unfair labor practice because of the involvement of management in a "labor organization." In addition, some managers are opposed to sounding boards on the theory that anything other than no union is too close to unionization.

Engineering unions are attempting to force sounding boards into an early grave. They, of course, feel this type of organization is a threat to union development. At the present time, Engineers and Scientists of America is campaigning for a change in the Taft-Hartley Act that would force "employers to cease dealing with other than legitimate unions on the subjects of wages, hours, and working conditions." The unions, very much on the defensive, claim "sounding boards are so dominated by management that, when the engineers' interests conflict with those of management, the engineer is forgotten."

Professional societies belonging to EJC are not enthusiastic about sounding boards, nor do they like any of the amendments to the T-H Act that would clarify the sounding board's legal position. The EJC feels it wisest to keep present advantages, rather than introduce new legislation which might upset the applecart.

Delaying Actions?

Although limited by tax laws, EJC societies are able to take action on "matters bearing on the welfare of the profession." Most societies have special committees that deal with employment practices, the most active being NSPE's Engineering in Industry Committee and ASCE's Committee on Employment Practices. In addition, EJC is now in process of forming its Committee on Engineering Practices.

Another activity initiated by NSPE is the annual presentation of the Industrial Professional Development Award to "the industrial employer of engineering personnel who has made an outstanding contribution to the advancement and improvement of the engineering profession." The award has two purposes:

- It gives recognition to firms who are pioneering in advanced engineering-employment practices.
- It encourages all managers to adopt progressive techniques.

In spite of these activities, some authorities feel that professional societies are fighting a losing battle. They fear the societies cannot provide for all the needs of engineers. Even though they are broadening their programs, the societies have no direct way of controlling the environment managers provide; they can only attempt to influence the managers.

Even though the societies are opposed to unionization, their spokesmen admit if unions are the only possible method of improving the engineer's situation, they will be condoned.

This article concludes the series. Parts one and two, appearing in the November 10 and November 24, 1960 issues of MACHINE DESIGN, discussed the choices available to the engineer, where unions stand today, and their plans for the future. The series was based on a report, *Engineers and Unions*, written by a team* from the Harvard Graduate School of Business Administration.

*Roger M. Atherton, Jr., S. Marc Altman, Lincoln Ames, K. Leo Ahlstedt, Albert E. Block, Jr., Ivan H. Enstrom, Jr., Richard D. Lockhart, Theophanes G. Pantazelos, John A. Smith, Robert T. Spahr.

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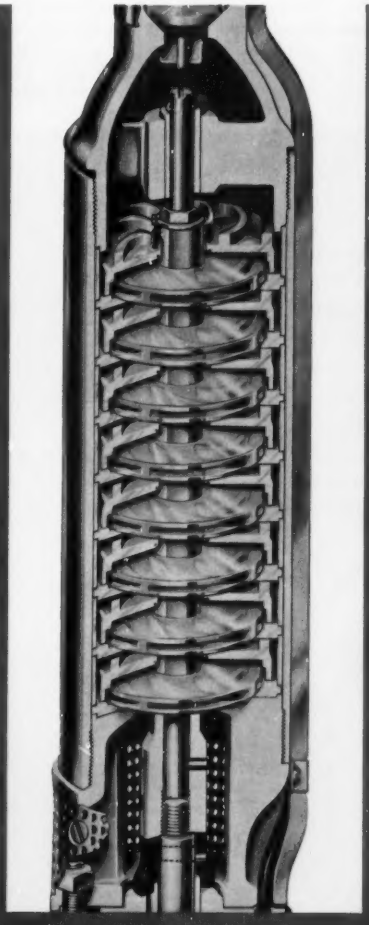

LEXAN IMPELLERS stand up where others fail because of Lexan's toughness, low water absorption and resistance to heat and abrasion. Acid, iron and sulphur waters do not halt submersible pumps made by The F. E. Myers & Bro. Co., Ashland, Ohio. (Molded by Michigan Panelyte Molded Plastics Div. of St. Regis Paper Co., Dexter, Mich.)

GENERAL ELECTRIC offers you more than 3 years experience in design and fabrication with this tough, rigid thermoplastic

Lexan's exceptional combination of properties includes:

- High impact strength
- Dimensional stability
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- Good electrical properties
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- Transparent
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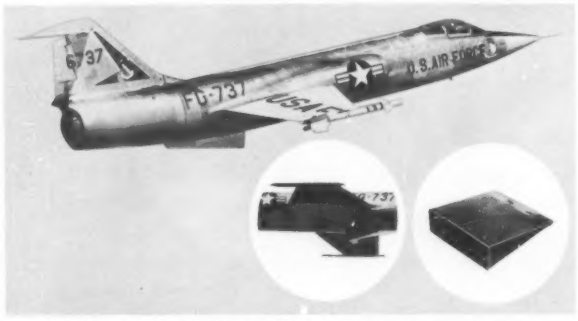
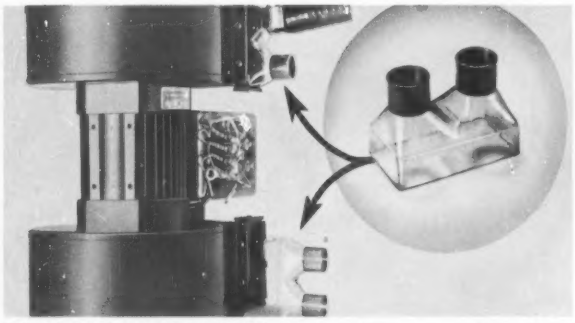
NOW TWO GENERAL ELECTRIC GIVE YOU LEXAN THERMOPLASTICS



HOUSINGS OF LEXAN thermoplastic protect riding lights on the trailing edges of Lockheed's F-104 Starfighter. The transparent resin withstands high friction caused by speeds of 1500 mph, thanks to its exceptional resistance to wear and heat. The material can take high-altitude cold. (Housings molded by Crescent Mold Engineering Corp., N. Hollywood, Calif.)



BLOWER COUPLINGS for radar unit are tough, flame-resistant . . . give smoother air flow than could formerly be obtained with brass fittings. Fabricated of LEXAN polycarbonate resin, they withstand cycling from −54°C to +54°C under humid conditions. Thuy are inexpensively vacuum-formed, allowing considerable savings in machining costs. (Used by the Tracking and Acquisition Radar Equipment Section of General Electric Company, Syracuse, N. Y.)

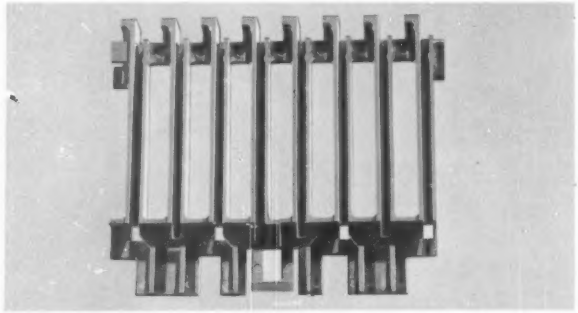
G. E. OPENS NEW LEXAN PLANT

Now, only G.E. offers two-plant flexibility in polycarbonates—a commercial plant and a semi-works plant for continued research and development in polycarbonate resins. The new plant, at Mount Vernon, Indiana, meets the increasing demand for LEXAN resins. The additional capacity, amounting to millions of pounds per year, makes General Electric the largest supplier of polycarbonate resins in the United States!

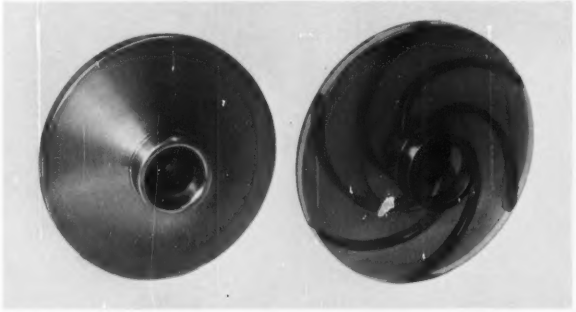
Pioneer in polycarbonates, G.E. has cooperated in the use of LEXAN resin in over 300 commercial applications. You can draw on this experience through G-E Technical Service. For a complete rundown on properties, uses, design considerations, molding and fabricating tips – send for LEXAN technical literature—the most complete literature on polycarbonates available! (*Coupon on page after next.*)

LEXAN—for designs that demand exceptional properties. If you want high strength and heat stability in a thermoplastic, use LEXAN polycarbonate resin. So tough is this material that it can actually be cold-formed and coined like a metal. It withstands over 12 foot-pounds per inch of notch—an impact strength attained by no other plastic. At the same time, LEXAN resin gives you a heat distortion point as high as 290°F! These properties are combined with outstanding dimensional stability, low water absorption, good electrical characteristics and other advantages.

LEXAN resin can be injection molded, extruded, vacuum formed, machined and bonded. It can be made into high-precision moldings, sheet, rod, tube, filament.

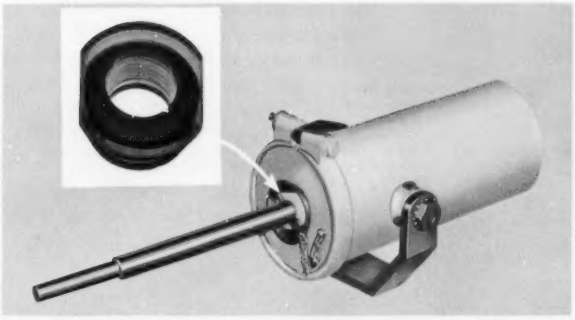


CARD GUIDE requires molding to close tolerances and minimum change in dimensions during service. Molded of LEXAN resin, the part shows excellent dimensional stability under varying conditions of moisture and at high temperatures. LEXAN resin is self-extinguishing—important in this application. (Molded for International Business Machines Corp. by Consolidated Molded Products Corp., Scranton, Pa. and Quinn-Berry Corp., Erie, Pa.)

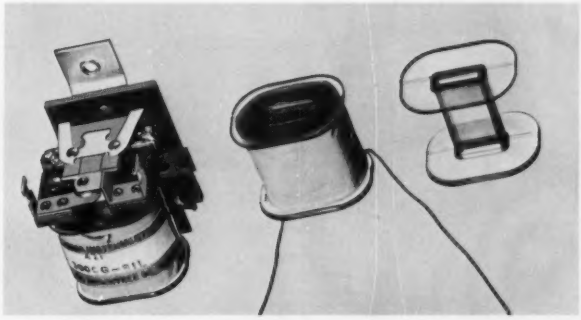


IMPELLERS molded of LEXAN resin replace bronze in jet pumps. Outperforming metal, LEXAN resin gives exceptional impact strength plus ability to withstand 280°F without distorting. LEXAN impellers withstant abrasive wear better than bronze and are unaffected by water or dilute acid. Impeller halves can be separately molded and then solvent-cemented. (Molded for Sta-Rite Products, Inc., Delavan, Wis. by Modern Plastics Corp., Benton Harbor, Michigan, and Santay Corp., Chicago, Ill.)

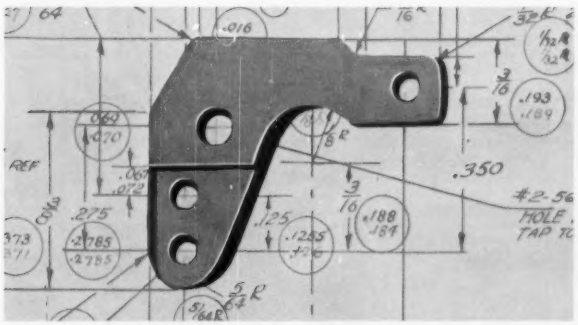
POLYCARBONATE PLANTS TO SOLVE PROBLEMS LIKE THESE



EMERGENCY-BRAKE BUSHINGS of LEXAN resin help trucks come to a safe stop. Before LEXAN bushings were used, the hole for the piston at the end of the activating cylinder quickly wore oblong, allowing road dirt to enter and cause leakage of the inner seal. The plastic's resistance to wear, heat and grease makes it ideal for this critical use. (Brake manufactured by MGM Brakes, Inc., Cloverdale, Calif. Bushings by Automatic Plastic Molding Co., Berkeley, Calif.)

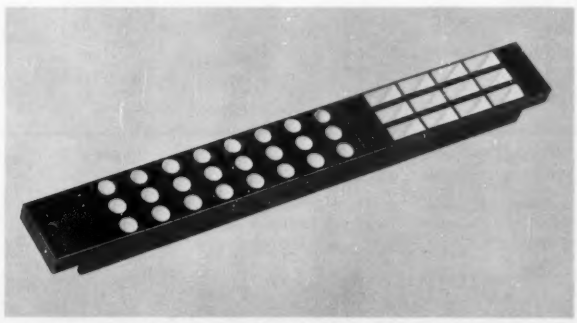


COIL FORM must not distort at temperature above 200°F under stresses caused by tightly wound wire. LEXAN resin provides heat distortion temperatures of 280-290°F under load. A good dielectric, LEXAN resin is resistant to oxidation at high temperatures and is non-corrosive even when used with very fine Class F magnet wire. (Molded for Sigma Instruments, Inc., So. Braintree, Mass. by Waterbury Companies, Inc., Waterbury, Conn.)

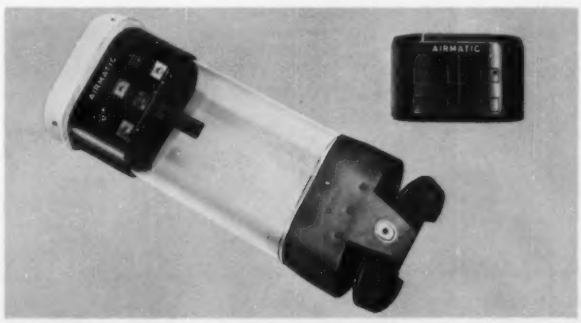


INSULATOR BLOCK of LEXAN resin helps insure trouble-free performance of electrical counter. Not much bigger than a dime, the part must maintain severe tolerances. It takes −85° to +280°F without distortion. The dimensional stability of LEXAN resin lowers cost of the part, permits replacement of materials which required costly machining to attain accurate dimensions. (Molded by Fred Knapp Engraving Co., Racine, Wis., for Abrams Instrument Corp., Lansing, Mich.)

FUSE HOLDER CAPS make use of the transparency and heat resistance of LEXAN polycarbonate resin. Lamp shining through LEXAN cover indicates blown fuse. Plastics previously used softened under the high temperature encountered in naval equipment. LEXAN resin was also selected for its good dielectric properties in the holder, which is rated up to 600 volts and 60 amps. (Molded by B&B Plastics, Oakville, Conn. and Engineered Plastics, Inc., Watertown, Conn. for Fuse Indicator Corp., Boston, Mass.)



LAMPHOLDER TERMINAL BLOCK is used inside electronic equipment where heat is difficult to dissipate. LEXAN polycarbonate resin replaced another thermoplastic which melted under severe thermal conditions. The part is molded with black resin and painted white in the lampholder holes. (Molded by Booker & Wallestad, Minneapolis, Minn. for Remington Rand Univac Div. of Sperry Rand Corp., St. Paul, Minn.)



"WARHEADS" for pneumatic tube systems take advantage of the high impact strength and dimensional stability of LEXAN resin. The good electrical properties of the thermoplastic permit placement of all electrical control elements in the head. LEXAN resin resists wear and tear and saves cost of repair and replacement in these parts, which undergo friction at speeds as high as 20 mph. (Molded for Airmatic Systems Corp., Saddle Brook, N. J. by Berkeley Engineering and Manufacturing Co., Berkeley Heights, N. J.)

PROPERTIES OF LEXAN POLYCARBONATE RESIN

	Property	Value	A.S.T.M. Test
PHYSICAL PROPERTIES	Color	Light amber, transparent	—
	Specific gravity	1.20	D 792
	Odor	None	—
	Taste	None	—
	Refractive index at 25°C	1.586	—
	Rockwell hardness	M70, R118	D 785
	Abrasion resistance, Taber abraser with CS-17 wheel	7–11 mg/1000 cycles	D 1044
	Impact strength, notched Izod, ⅛" specimen	12–16 ft-lb/in. of notch	D 256
	Impact strength, unnotched Izod, ⅛" specimen	>60 ft-lb/in.	D 256
	Tensile-impact	600–900 ft-lb/cu in.	—
	Tensile yield strength	8,000–9,000 psi	D 638
	Tensile ultimate strength	9,000–10,500 psi	D 638
	Tensile modulus	320,000 psi	D 638
	Elongation	60–100%	D 638
	Compressive strength	11,000 psi	D 695
	Compressive modulus	240,000 psi	D 695
	Flexural strength	11,000–13,000 psi	D 790
	Flexural modulus	375,000 psi	D 695
	Shear yield strength	5,400 psi	D 732
	Shear ultimate strength	9,200 psi	D 732
	Light transmission (⅛ in. thick disc)	75–85%	—
	Water vapor permeability	$3–4 \times 10^{-6}$ g/cm/hr/cm²/mm Hg	—
	Nitrogen permeability	0.012×10^{-6} cc(STP)/mm/sec/cm²/cm Hg	—
	Carbon dioxide permeability	0.32×10^{-6} cc(STP)/mm/sec/cm²/cm Hg	—
	Bulk factor of pellets	1.7	—
	Poisson's ratio	0.38	—
	Modulus of rigidity	116,000 psi	—
	Deformation under load, 4000 psi 77°F	0.2%	D 621
	158°F	0.3%	
	Fatigue endurance limit (Wohler method), 1800 cycles/min., 73°F, 50% RH	2000 psi	
	Water absorption, 24 hr. immersion	0.2%	D 570
	equilibrium 73°F	0.35%	
	equilibrium 212°F	0.58%	
THERMAL PROPERTIES	Heat distortion temperature	264 psi: 280°–290°F 66 psi: 283°–293°F	D 648
	Mold shrinkage	0.005–0.007 in./in.	D 955
	Thermal conductivity	4.6×10^{-4} cal/sec/cm²/°C/cm	—
	Coefficient of linear thermal expansion	3.9×10^{-5} in./in./°F	D 696
	Flammability	Self-extinguishing	D 635
	Brittle temperature	<−135°C	D 746
	Specific heat	0.30	Bulletin 157

Deformation under load on 0.5 in. cube	Temp., °F	Load, lb	Deformation, %	
	158	1000	0.282	D 621
	158	500	0.080	
	77	1000	0.220	
	77	500	0.101	

ELECTRICAL PROPERTIES		−30°C	−3°C	23°C	100°C	125°C	A.S.T.M. Test
	Dielectric constant						
	60 cycles	3.12	3.14	3.17	3.15	3.13	D 150
	10^6 cycles			2.96			D 150
	Power Factor						
	60 cycles	0.005	0.004	0.0009	0.0009	0.0011	D 150
	10^6 cycles			0.010			D 150
	Volume resistivity, ohm-cm	$>10^{17}$	$>10^{17}$	2.1×10^{16}	2.1×10^{15}	2.7×10^{14}	—
	Arc resistance,						D 495
	stainless steel strip electrodes			10–11 sec			
	tungsten electrodes			120 sec			

	25°C	100°C	
Dielectric strength, short time	3,910 v./mil at 1.5 mils 3,080 v./mil at 3.0 mils 2,560 v./mil at 4.7 mils 1,130 v./mil at 23.0 mils 400[a] v./mil at 125.0 mils	3,380 v./mil at 3.0 mils 1,250 v./mil at 23.0 mils 600[a] v./mil at 125.0 mils	D 149
Resistance to electron beam radiation	No change up to 5×10^7 r dosage		

([a]The step-by-step values are essentially the same as the short time values for the 125-mil pieces)

Chemical Materials Department, Section MD
General Electric Company, Pittsfield, Mass.

☐ Send me literature on LEXAN resin

☐ My application area of interest is_____

Name_____

Title_____

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CHEMICAL MATERIALS DEPARTMENT • PITTSFIELD, MASS.

Single-Engine Skywagon Carries Six

WICHITA, KANSAS—Designed to fill high-payload mission requirements, Cessna's new model 185 utility plane is powered by a Continental fuel-injection engine rated at 260 hp. Besides the six-place version, 185 optional interiors include a pilot-only freight model and four-place utility and deluxe models.

Equipped with conventional gear, the 185 is ideally suited for passenger, charter and feeder line work, cargo hauling, agricultural work, and long-range mapping operations.

The Cessna ¾ in. spring-steel landing gear comes with a choice of 6.00 x 6 or 8.00 x 6 wheels and brakes. Instrument panel is designed to the "eyes on the road" concept, with flight instruments placed directly in front of the pilot. The radio is mounted in the center of the flight panel.

The 185, designated the Skywagon, has an empty weight of 1520 lb. Top speed is 176 mph, and the service ceiling of the new model is 17,300 ft.

Capable of carrying six adults plus 270 lb of extra baggage, the 1961 Cessna model 185 is certified for standard gear, ski, and float operations. Price: $18,950 for standard equipped airplane.

Skywagon Performance Summary			
Gross weight	3200 lb	*Rate of Climb (sea level)*	1000 fpm
Speed (max cruise)	165 mph	*Take-off (50-ft obstacle)*	1510 ft
Range (normal lean)	770 miles	*Wing Span*	36 ft
Power (at 2625 rpm)	260 hp	*Length*	26 ft 2 in.

Metals Matters

Improved plating process . . .
developed by the Udylite Corp., Detroit, results in a sulfur-free, semi-bright nickel coating. An advantage of the new process is the lack of "breakdown" products—organic materials, oxidized or reduced during plating—which are likely to impair the finish. Process is simple, economical, and provides a durable finish.

Anti-friction properties . . .
of new metal-bonded graphite materials suggest their use for both dry and externally lubricated bearings. The Scientific Laboratory of Ford Motor Co., developer, uses conventional powder-metallurgy techniques to produce the materials. Graphite-rich compositions suitable for dry bearings have shown strength superior to the best strengths of pure graphite, improved mechanical properties, and close dimensional control of parts. Also, they can be made by high-volume powder metallurgy production techniques.

One-shot color coatings . . .
can be applied to almost any metal, at room temperature, and in an aqueous solution. Put on by roller coating, dip, or spray, Hinac coatings cure in a few seconds with certain heat sources. Besides colors, the coatings are available in two weights of clear finish. They are resistant to acids, alkalis, and solvents. Developer of the process, Pennsalt Chemicals Corp., Philadelphia, claims considerable economy over color anodizing or painting.

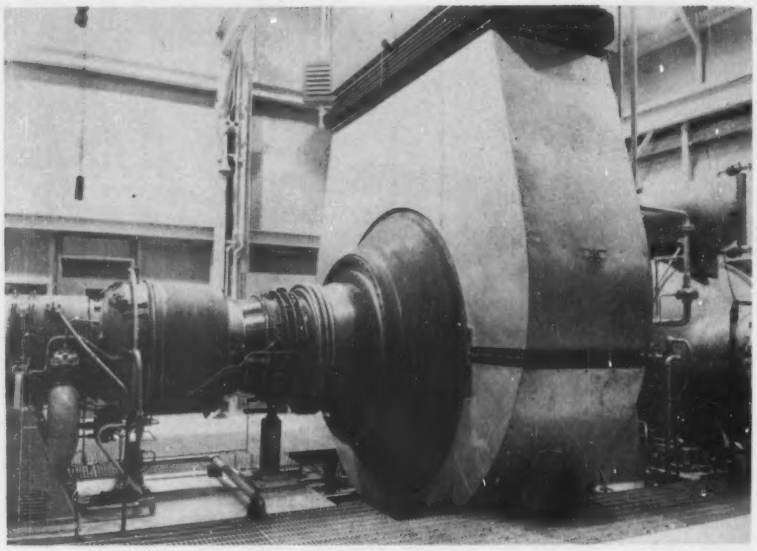
Anti-smog alloy steel . . .
nominally 21 per cent chromium, 6 per cent nickel, and 9 per cent manganese, was developed by Armco Steel Corp. for devices being built as a result of California's new air-pollution legislation. In tests, Armco 21-6-9 demonstrated strength at high temperatures, resistance to lead salt attack. It can be worked and fabricated by conventional techniques and equipment.

Titanium usable at 900 F . . .
in jet engines is introduced by Titanium Metals Corp. of America. The alloy contains 8 per cent aluminum, 1 per cent molybdenum, 1 per cent vanadium. It provides excellent creep resistance and rupture life and, because of the high aluminum content, its density is somewhat lower than that of most titanium alloys.

Data on superalloy WI-52 . . .
obtained from private companies, has been published by the Office of Technical Services. Included are details on specifications and names of the alloy, chemical composition, fabrication, oxidation resistance, physical properties, and mechanical properties. The DMIC Memorandum, PB 161217 *Physical and Mechanical Properties of the Cobalt-Chromium-Tungsten Alloy WI-52*, can be obtained for 50 cents from OTS, U. S. Dept. of Commerce, Washington 25, D. C.

←Circle 418 on Page 19

Jet-Powered Gas Pump

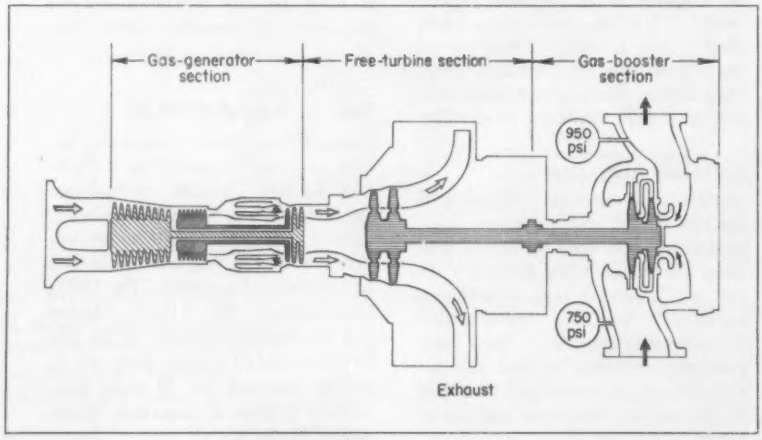


First application for a family of gas turbines is the pipeline compressor, above. Rated from 350 to 15,000 hp, the powerplants are expected to be widely used in the natural gas and petroleum industries and in electrical power generating.

POSSUM TROT, KY. — After years of impressive service as a military and commercial aircraft powerplant, the high-flying turbojet engine has finally been coaxed into a relatively tame job on the ground. Its performance in the new environment is as spectacular as ever, according to Cooper - Bessemer Corp., Mt. Vernon, Ohio.

The company designed a radical new turbine-powered centrifugal compressor for the pipeline industry using a modified Pratt & Whitney J-57 engine as the gas generator. The complete unit develops 10,500 rotative horsepower and weighs about 1/6 as much (34,000 lb vs. 204,000 lb) as a conventional unit. It is currently pumping 600 million cubic feet of natural gas a day in a pipeline compressor station of the Columbia Gulf Transmission Co.

Adapted to run on natural gas, the dependable J-57 never reaches jet takeoff speeds, temperatures, or stresses. It operates at or below flight cruising speed. As a result, the designers estimate that the jet section of Cooper-Bessemer's turbine will run at least 8000 hours between overhauls — equivalent to a full year of continuous operation.



No regenerator is needed by the jet power plant, although it operates at 25 per cent efficiency. High (10 to 1) compression ratio of the J-57 is the main reason.

Industry Progress Highlighted at NEMA Meeting

NEW YORK — Four top scientists have reviewed accomplishments in the electrical field during the last decade and concluded that the entire electronics industry is in the midst of a revolution.

Speaking at the National Electrical Manufacturers 34th annual meeting, Dr. H. Trotter Jr., president, General Telephone and Electronics Labs, discussed new advances in lighting resulting from materials research. In particular, he pointed out that fluorescent lighting has improved in efficiency by over 30 per cent in the last decade, as well as being more like daylight than it was in 1950. He also explained the research efforts that led to development of the M-5 and M-25 flashbulbs, using zirconium instead of aluminum foil filler.

S. W. Herwald, vice president research, Westinghouse Corp., summed up the current materials problems in applying methods of direct power conversion to nuclear reactors. He pointed out that, although tremendous problems must be solved before direct conversion is economically feasible, the rewards fully justify the huge expenditures on them.

Dr. W. R. Hibbard Jr., Manager, Metallurgy and Research Dept., General Electric Co., described the electrical industry as one which is historically dependent on new technologies for its growth. New materials must, to a large extent, come from within the industry, because of their specialized nature, and because of industry's diversity.

Dr. F. J. Larson, vice president of research, Minneapolis-Honeywell Regulator Co., explored reasons for the shift of research discoveries from campus to industrial park.

Universities now compete with industry for development contracts which occupies a large proportion of their available staff. This forces the industrial company to set up its own research facilities, since most development nowadays utilizes newly discovered knowledge. The electrical industry will spend an estimated $4 billion for research and development work in 1960—not including work paid for by the government.

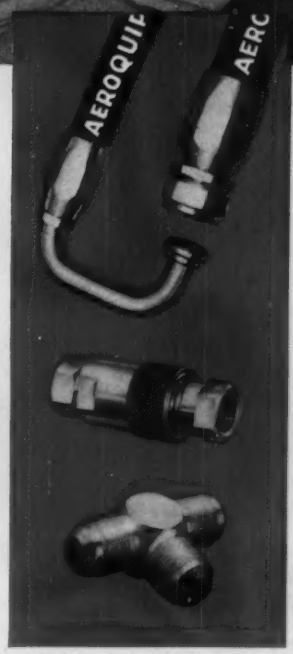
Aeroquip Fluid Piping Service Assists Product Design Engineers

Major equipment manufacturers can use Aeroquip's Fluid Piping Service to great advantages in developing fluid systems that will provide dependable, trouble-free service in the field. Highly qualified Aeroquip Sales Engineers, for example, are on call to furnish valuable design assistance. Working right in your engineering department, these fluid piping design specialists give you the full benefits of the experience Aeroquip has gained by working with many other manufacturers.

This design assistance is only part of Aeroquip's complete service. Backed by the most complete line of fluid piping products, Aeroquip's specialists can also help you mock up and test systems, work with your production planners and expediters and assist in developing a service parts program. Aeroquip can even furnish trained field service engineers to assist in after-sales service on your equipment.

For detailed information, call your nearby sales engineer, or write to us.

Aeroquip fluid piping specialists can work with you in every phase of manufacture to assure maximum performance of fluid piping systems on your products.



Aeroquip now produces a wide range of fluid piping products, including hose assemblies with standard or special tube configuration fittings, Self-Sealing Couplings and a new line of tube fittings.

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Circle 419 on Page 19

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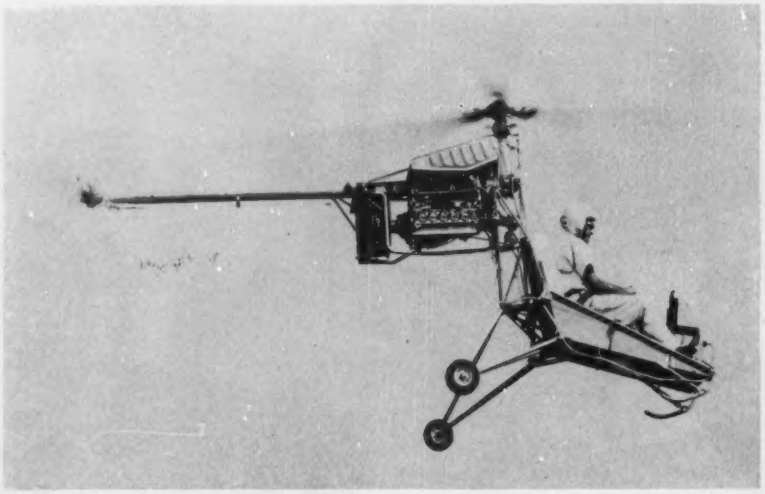


Specialist at No Altitude

Capable of lifting its own weight (300 lb) in payload, or soaring to 10,000 ft, this one-man helicopter can also stage an impressive performance without leaving the ground. Mounted on a movable platform and equipped with "false-feel" devices, the craft can simulate the dynamic-flight characteristics of any helicopter. The platform "flys" across the ground, but cannot be overturned, while a simple mounting mechanism permits the 'copter to tilt in any direction or rotate about its vertical axis. Control-system configuration of the trainer is identical to large helicopters, so the student pilot can graduate to dual instruction in a full-size craft, or detach the platform and solo in the trainer. Del Mar Engineering Laboratories, Los Angeles designed the Whirlymite and its platform.

"Rover" Rockets Requested

Nuclear Propulsion Program Making Rapid Progress

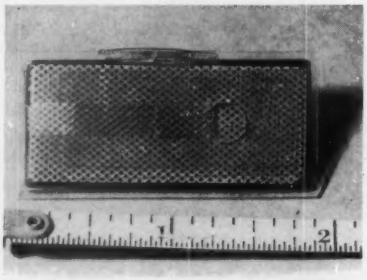
WASHINGTON — Success of Kiwi-A3 may be behind the decision by NASA and AEC to skip a step in the nuclear-rocket program.

NASA has announced that a request for proposals will be sent to manufacturers for research and development of a nuclear rocket engine. The nuclear rocket program (Project Rover), a joint responsibility of NASA and AEC, is managed by the joint AEC-NASA Nuclear Propulsion Office, established August 31, 1960.

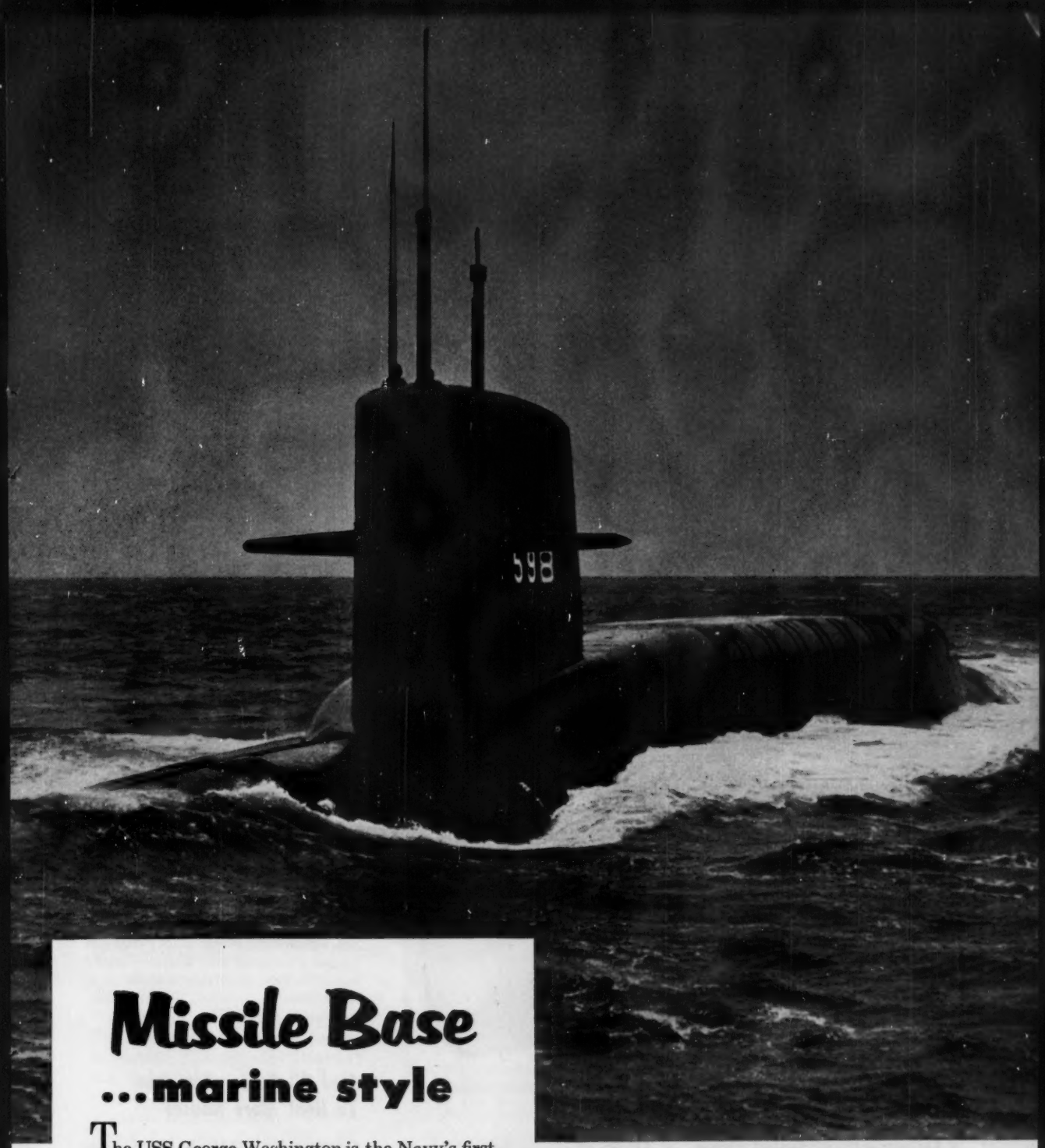
Completed experiments to date include three nuclear reactors. Kiwi-A3, which uses high-pressure hydrogen for its propellant, was successfully tested on October 19 by its designer, the Los Alamos Scientific Laboratory.

The decision to select a contractor to provide engineering support and conduct research and development of the engine cancels an earlier NASA request for proposals on a six-month preliminary design study.

Long Life for Lightweight



Infinite storage life is claimed for a lightweight primary cell recently developed for use in extreme-temperature environments. Indium-bismuth alloy, replacing a conventional zinc anode in the cell, is more stable at high and low temperatures by virtue of its low solubility in the electrolyte alkali. It is being produced by Metachemical Processors, Ltd., div. of Sifco, Cleveland, for missile applications in the British defense program.



Missile Base
...marine style

The USS George Washington is the Navy's first submarine equipped to fire the Polaris missile from submerged positions.

Like the Patrick Henry, Nautilus, Triton, Sea Wolf and other nuclear-powered submarines, the George Washington contains equipment fabricated from stainless steel plate produced by Carlson.

It will be to *your* advantage to specify Carlson stainless steel plate and plate products. Our specialists produce exactly what you want and deliver it to you on schedule. Contact Carlson now.

USS George Washington now "on station" with the fleet!
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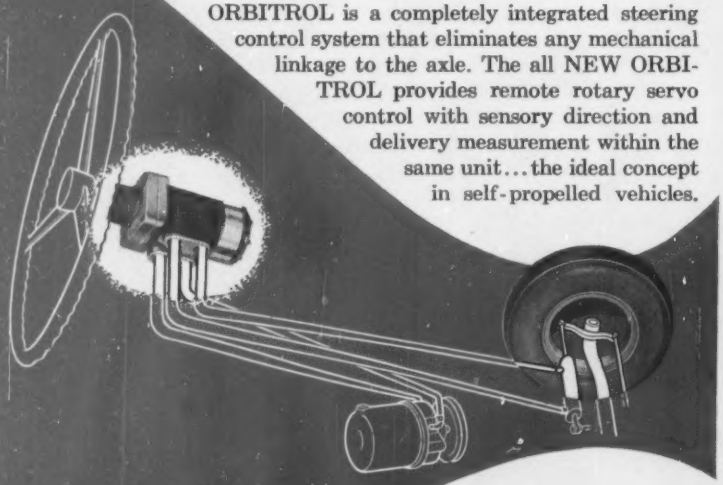
NEW FLUID STEERING

REPLACES ENTIRE MECHANICAL STEERING SYSTEM

ORBITROL is a completely integrated steering control system that eliminates any mechanical linkage to the axle. The all NEW ORBITROL provides remote rotary servo control with sensory direction and delivery measurement within the same unit... the ideal concept in self-propelled vehicles.



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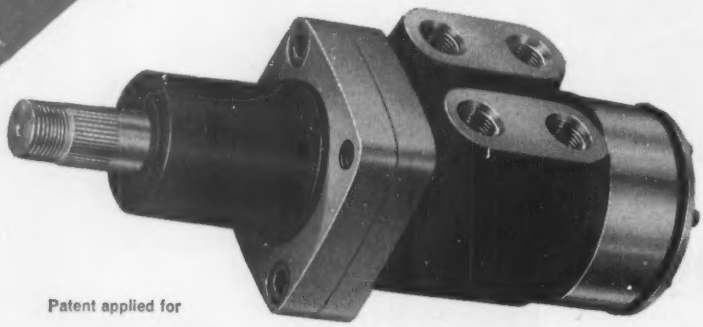
ORBITROL

ORBITROL can be used with any remote actuator, such as a linear cylinder, rotary cylinder, or hydraulic motor. With power off, ORBITROL becomes a pump to furnish means for emergency steering.



Patent applied for

10 Good Reasons for Choosing Char-Lynn ORBITROL for Your Control Needs

- Replaces entire mechanical steering system
- Direct acting—not a booster
- Operates with power off
- Optional steering arrangements
- Easy to install—compact size
- Allows design flexibility • Sound axle design
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- Reduces maintenance
- Highly responsive

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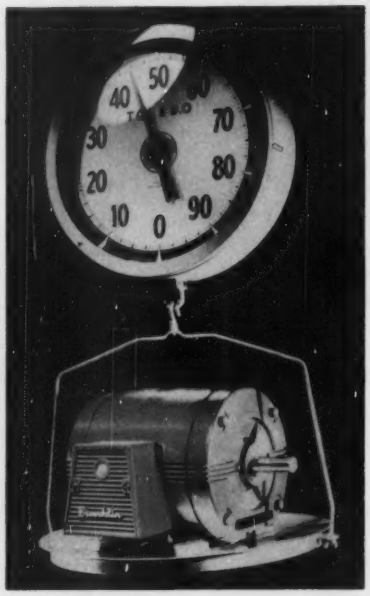
Aluminum Motor Gives More Power per Pound



An aluminum electric motor now in production will permit weight-savings in the design of pumps, compressors, and other motor-driven machinery. Franklin Electric Co., Bluffton, Ind., claims its integral horsepower motor is 30 per cent lighter than cast-iron motors of the same rated capacity, and is structurally stronger. Other advantages include improved heat transfer and better corrosion resistance. Frame, end-bells, bearing caps, rotor, and conduit box are all aluminum alloys. The lightweight motor also introduces unique prepacked and double-shielded bearings that positively exclude contamination.

Fuel Oil Researchers Aim To Heat More Houses

CHICAGO—Liquid fuels are looking for a bigger share of the residential-heating market. Co-operative research efforts of the entire oil industry, integrated by top specialists of the American Petroleum Institute, are aimed at developing, interpreting, and disseminating technical information on improved equipment.

An API Fuel Oil subcommittee report outlines objectives for the new program:

- Seek new principles in fuel-oil

Circle 421 on Page 19

combustion
- Interpret new findings in terms of practical applications
- Review new and old principles with a view to their greater exploitation
- Solve development problems
- Demonstrate new prototype equipment
- Present research results in useful form to commercial manufacturers

The program will cover only those areas that are not likely to be investigated by the manufacturers themselves, the committee emphasized, and no final equipment designs will be pursued.

The scope of the proposed research program was determined by an independent survey conducted by a team of Battelle Memorial Institute scientists.

Meetings and Shows

Dec. 17—

Institute of the Aerospace Sciences. Wright Brothers Lecture to be given at the Natural History Bldg. Auditorium, Smithsonian Institution, Washington, D. C. Further information can be obtained from IAS headquarters, 2 E. 64th St., New York 21, N.Y.

Jan. 9-13—

Society of Automotive Engineers Inc. International Congress and Exposition of Automotive Engineering to be held at Cobo Hall, Detroit. Additional information is available from the society, 485 Lexington Ave., New York 17, N. Y.

Jan. 17-19—

Instrument Society of America. Winter Instrument - Automation Conference and Exhibit to be held at the Sheraton-Jefferson Hotel and Kiel Auditorium, St. Louis. Further information can be obtained from ISA headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

Jan. 23-25—

Institute of the Aerospace Sci-

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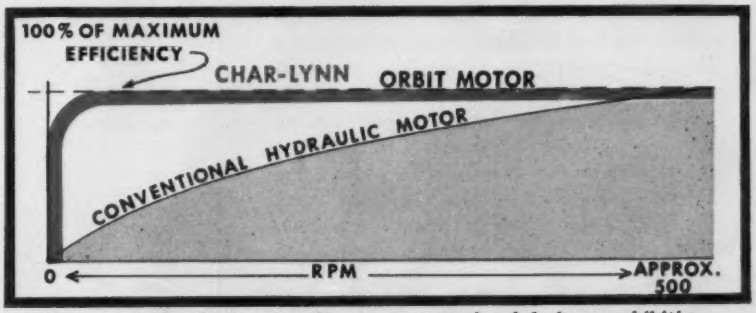
A High Torque, Low Speed Hydraulic Motor

It's Here—A NEW concept in fluid power mechanics has brought about the development of a totally new fluid motor—A *High Torque—Low Speed* motor.

These motors open up complete new areas for design, never before possible. They offer a practical and economical hydraulic solution to the age-old problem of providing High Torque at Low Speeds for constant and variable speed drives—hydrostatic transmissions and remote controls *without* bulky, costly mechanical drives and gear reducers.



Whereas hydraulic losses make some conventional designs prohibitive at the lower speeds, Char-Lynn ORBIT MOTORS maintain high efficiency over the complete operational range.

- Speeds from 0—800 RPM
- Torques to 3300 inch lbs.
- Starting torque substantially equal to running torque
- Fully reversible — instantaneous starting—stopping
- Only 3 moving parts
- 4 types of mountings available
- 3 port sizes—7 power element selections
- Compact—lightweight
- Eliminates costly and complicated power transmissions
- High volumetric and overall efficiency

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new SPACEMAKING Perfection VACUUM PUMP

Solves design problems wherever you need vacuum

Fewer Parts — Easier Service

It's what's inside that counts! And inside the new Perfection Vacuum pump you'll find a space-saving rotor with exclusive rotor slots that permit longer vanes, longer wear. Vanes slide freely, hug pump housing periphery, providing closer seal, higher efficiency. This simplified design permits easy removal of vanes for cleaning or replacement without disturbing pump piping or motor mounting. Many other exclusive features.

Tell us your vacuum pumping needs. Perfection can simplify original equipment design, cut costs, too.

WIDE RANGE OF SIZES	MOTOR HP	FREE AIR
	¼	2.50 c.f.m.
	⅓	5.0 c.f.m.
	½	9.0 c.f.m.

Larger, belt-driven models also available, delivering up to 36 c.f.m. at 0" Hg.

HUNDREDS OF USES

- Bubble pack and skin pack packaging.
- Poultry and food packaging machines.
- Vacuum chucks on lathes.
- Vacuum drawing of plastic sheets.
- Vacuum impregnation of ferrous castings.
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- Filling culture tubes and ampules.
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- Vacuum backs on cameras.
- Feeding printing presses and folding machines.
- Pad applicators.
- Many other uses.

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ences. Annual Meeting to be held at the Hotel Astor, New York. Honors Night Dinner is Jan. 24. Further information is available from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Jan. 29-Feb. 3—

American Institute of Electrical Engineers. Winter General Meeting to be held at the Hotel Statler, New York. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Feb. 1-3—

Second Winter Military Electronics Convention to be held at the Biltmore Hotel, Los Angeles. Sponsors are the National Professional Group on Military Electronics and the Institute of Radio Engineers, Los Angeles section. Additional information is available from IRE, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

Feb. 7-9—

Society of the Plastics Industry Inc. Sixteenth Reinforced Plastics Div. Conference to be held at the Edgewater Beach Hotel, Chicago. Further information can be obtained from SPI headquarters, 250 Park Ave., New York 17, N. Y.

Feb. 13-16—

American Society of Heating, Refrigerating and Air-Conditioning Engineers. National Meeting and 15th International Heating & Air-Conditioning Exposition to be held at the International Amphitheatre, Chicago. Additional information

"Now we know what's been happening to those linen tracings."

can be obtained from exposition headquarters, 480 Lexington Ave., New York 17, N. Y.

Feb. 26-March 1—

First Pacific Electronic Trade Show to be held in the Great Western Exhibit Center, Los Angeles. Additional information can be obtained from PETS headquarters, 2216 South Hill St., Los Angeles 7, Calif.

March 11-14—

Steel Founders' Society of America. Annual Meeting to be held at the Drake Hotel, Chicago. Further information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

March 13-17—

Society of Automotive Engineers Inc. National Automobile and Production Meetings to be held at the Sheraton-Cadillac Hotel, Detroit. Further information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

March 13-17—

National Association of Corrosion Engineers. Annual Conference to be held at the Statler Hotel, Buffalo. Additional information can be obtained from NACE headquarters, 1061 M & M Bldg., Houston 2, Tex.

March 20-24—

American Society for Metals. Thirteenth Western Metal Exposition & Congress to be held at the Pan Pacific Auditorium, Los Angeles. Additional information can be obtained from ASM, Metals Park, Novelty, Ohio.

Short Courses and Symposia

Jan. 9-11—

Seventh National Symposium on Reliability and Quality Control to be held at the Bellevue-Stratford Hotel, Philadelphia. Sponsors are the Institute of Radio Engineers, American Institute of Electrical Engineers, American Society for Quality Control, and Electronic Indus-

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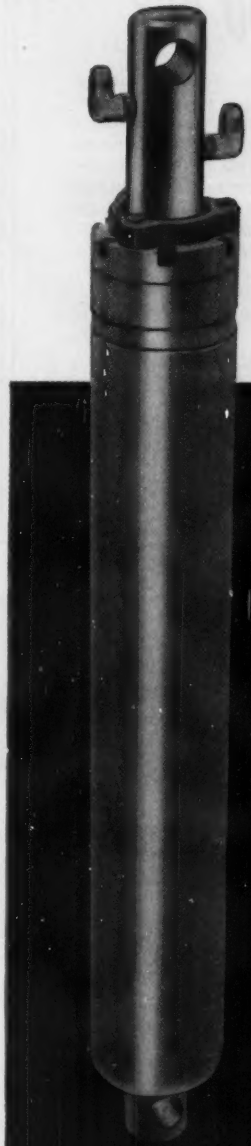
your job



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Circle 424 on Page 19

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Circle 425 on Page 19

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DOUBLE DUTY! Disconnects one electrical circuit while placing the other in operation. Industry-approved for a wide range of applications in dual circuit activation of various types of instruments, warning signals, safety devices, fuel pumps — in many other ways for making and breaking circuits. Ideal for locking out a starting motor while the engine is running. Can be used with oil or air . . . or with standpipe, almost any liquid or gas.

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tries Association. Additional information can be obtained from James H. Goodman, Radio Corp. of America, Bldg. 1-2, Camden 2, N. J.

Jan. 11-12—

Quality Control Seminar, sponsored by the American Society of Tool and Manufacturing Engineers, to be held at the Chase Park Plaza, St. Louis. Additional information can be obtained from ASTME headquarters, 10700 Puritan Ave., Detroit 38, Mich.

Jan. 18-19—

Seminar on Machining and Forming Space-Age Metals to be held at the Statler-Hilton Hotel, Dallas. Sponsor is the American Society of Tool and Manufacturing Engineers, and further information can be obtained from the society, 10700 Puritan Ave., Detroit 38, Mich.

Jan. 23-Feb. 2—

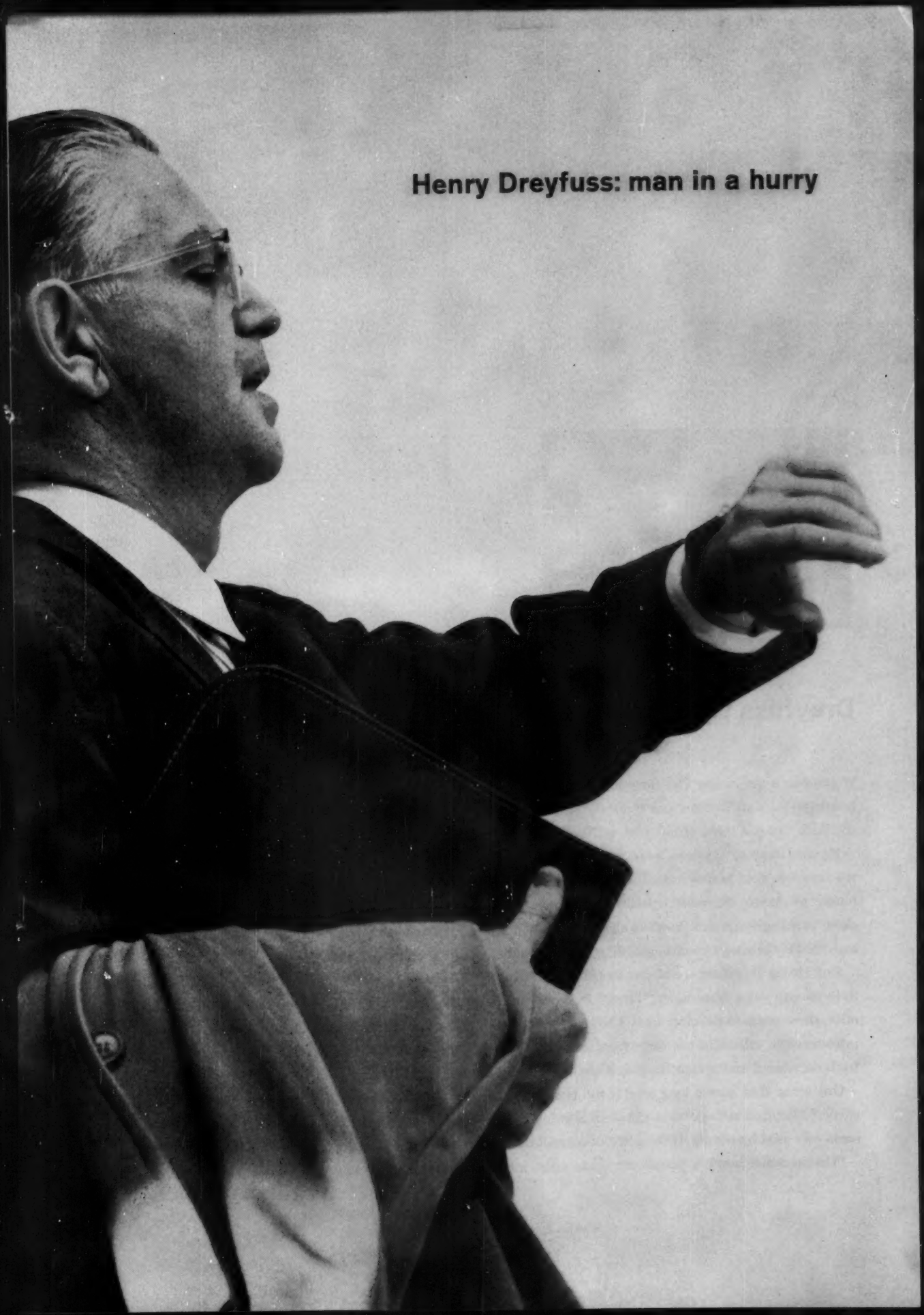
Engineering and Management Course to be held at UCLA. Participants select four classes from a group of 22, including such subjects as reliability for modern industry, industrial psychology, engineering and research administration, and effective managerial communication. Public speaking classes are also offered. Further information can be obtained from Reno R. Cole, Co-ordinator, The Engineering and Management Course, College of Engineering, University of California, Los Angeles 24, Calif.

March 20-31—

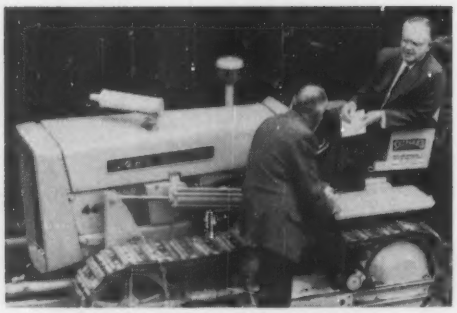
Industrial Packaging Short Course to be held at Purdue University. Additional information is available from Mark E. Ocker, Conference Co-ordinator, Div. of Adult Education, Memorial Center, Purdue University, Lafayette, Ind.

March 27-31—

Third Symposium on Temperature —Its Measurement and Control in Science and Industry to be held at Veterans Memorial Auditorium, Columbus, Ohio. Sponsors are Instrument Society of America, American Institute of Physics, and National Bureau of Standards. Further information is available from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.



Henry Dreyfuss: man in a hurry



Dreyfuss talks design

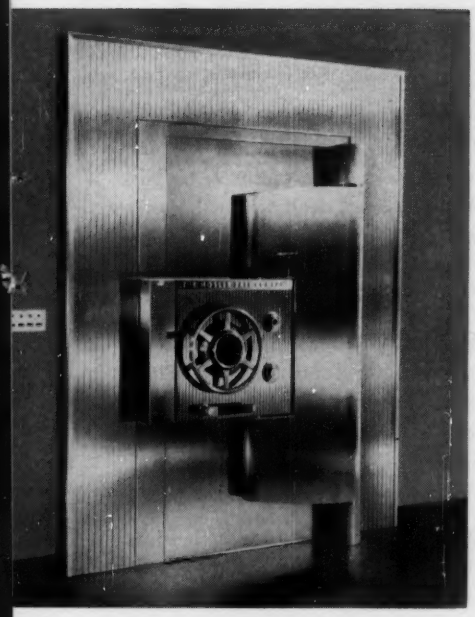
If you could get Henry Dreyfuss to sit still long enough for a caricature, the drawing would inevitably show him with his coat half on and briefcase in hand. Most likely, he would be on his way to the airport. He's on the East Coast a third of his time, on the West Coast a third, and the other third in between.

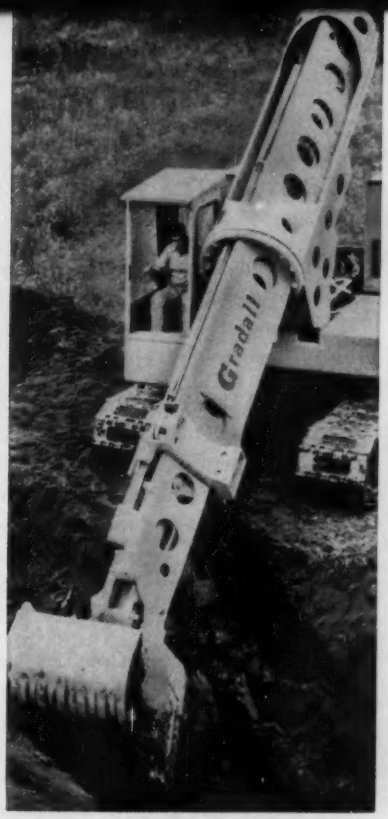
Henry Dreyfuss has been busy ever since he gave up scenery design in the late Twenties and helped pioneer the business that is now called industrial design. In the early days, he gave a new look to everything from hinges to pianos, cigarette lighters to tractors. Today he can look back on a career of redesigning vacuum cleaners and gas stations, bowling alleys and ship interiors, typewriters and dental equipment, magazine formats and military strategy rooms, plumbing fixtures and the Nike missile launcher.

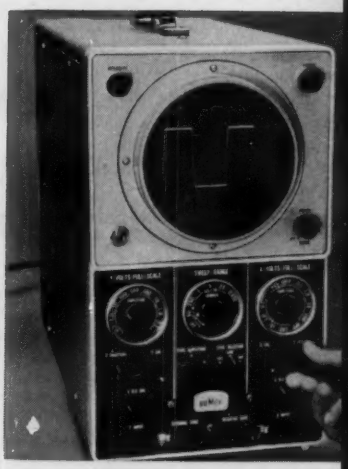
But Henry Dreyfuss is not one to look back. There are designs on his boards today that will influence our lives twenty years from now. "Time," he says, "is one of the designer's big problems. A design assignment is often three years in development. The item may not be on the market for another three to ten years. After it's introduced it will be in use for any number of years. In order to design that far ahead, our ideas have to be fresh, advanced and sprightly. It is a challenge to have to think as far ahead as we do."

One thing that goes a long way is the Henry Dreyfuss design credo, and it is all about people. "It says in effect," Dreyfuss states, "that the item is going to be ridden in, sat on, looked at, talked into, operated or in some way used by people. If the point of contact between the product and people causes friction, we have failed.

"On the other hand, if people are made safer, more comfortable, more eager to purchase, more efficient, or







just plain happier—we have succeeded." And succeed Dreyfuss does, by following this yardstick for effective industrial design: 1. Safety and convenience of use. 2. Ease of maintenance. 3. Cost, including tooling, production and distribution. 4. Sales appeal. 5. Appearance.

Selection of the right material for the job plays an important role in satisfying each of the five requirements. As a matter of ethics and sheer common sense, Henry Dreyfuss, like any member of the American Society of Industrial Designers, will not endorse any one material. "We have worked with all materials. What we want is the material that is right for the job. We look for the material that combines reasonable cost with the ability to be fabricated economically, and at the same time will give the product the built-in quality and durability it needs to sell well." With no-nonsense requirements like that, it is not surprising that a great many Dreyfuss-designed products use steel in one way or another.

Steel has strength, integrity and honesty. Steel is what the designer is apt to call a 'natural.' Dreyfuss feels that the public's image of steel depends largely on the product itself. A massive steel vault door conjures up an image of strength, imperviousness. Stainless Steel tableware suggests style and modernity. Steel curtain wall panels give buildings the look of tomorrow.

The moral is this: steel has been with us for ages, yet it is the modern metal, the metal of the future. Its enduring modernity will continue to be recognized, and used, by designers like Henry Dreyfuss.

(*turn the page for a new look at steel*)

USS TRADEMARK **United States Steel**

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

designing with USS High Strength Steels

Good design goes beyond material selection. Once the choice has been made, the designer's job is to take full advantage of the material's properties. Few materials offer designers as much opportunity as high strength steels.

COR-TEN Steel was developed by U.S. Steel and first used in 1933.

USS COR-TEN Steel is a name that has become a byword in design circles. It is a time-tested, high strength low-alloy steel. Structural designers welcomed COR-TEN Steel because it allowed them to pare dead weight and to lower maintenance costs. As structures, mobile equipment and machinery got bigger and bigger, dead weight became more of a problem. Even when weight could be shaved without stress problems, durability suffered. This high strength steel answered both problems.

Dead weight in stationary structures is costly; in mobile equipment dead weight requires more power to move.

USS High Strength Steels' yield points are all 50,000 psi min. compared to 33,000 psi for structural carbon steel.

Strength did it. COR-TEN brand and other USS High Strength Steels have a 50% higher yield point than structural carbon steel. They permit as much as 33% weight reduction. They have superior resistance to atmospheric corrosion and abrasion, so there is little reason to overdesign. Their fatigue and impact properties are excellent. Here is a quick look at three well-known USS High Strength Steels:

Send for the manual described at the right for a comprehensive guide on how to design with high strength steels.

USS COR-TEN Steel has a yield point 50% greater than structural carbon steel, has four to six times its resistance to atmospheric corrosion. It is used to do any one of these three things: 1) in slimmer sections to cut weight at no strength loss; 2) in equal sections to increase load-carrying capacity, cut maintenance and lengthen life; and 3) any number of combinations of 1 and 2. COR-TEN Steel also has greatly superior paint adherence and is used where a longer interval between repainting is wanted.

USS TRI-TEN Steel, with its 50% higher yield point than structural carbon steel, has superior notch toughness at low temperatures and keeps rugged equipment operating even in sub-zero weather. Its high endurance limit makes TRI-TEN Steel ideal for mobile equipment that must take repeated loading and reversals of stress. It is a natural for welded structures and bridges.

MAN-TEN Steel costs only about 20% more than structural carbon steel; TRI-TEN Steel about 36% more, and COR-TEN Steel 42% more.

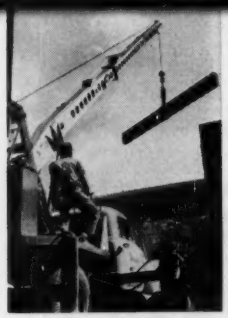
USS MAN-TEN Steel also has a 50% higher yield point than structural carbon steel, and is the low-cost member of the family. Weight reduction as little as 17% with MAN-TEN Steel will save money on material cost alone. MAN-TEN Steel is a tough, durable steel and widely used in earthmoving equipment, truck frames, material handling apparatus and riveted bridges.

High strength steels represent but a few of the over 3000 grades of steel in existence today. United States Steel makes a complete line of high strength steels, as well as constructional alloy, stainless and carbon steels. Bring your design problems to us. United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

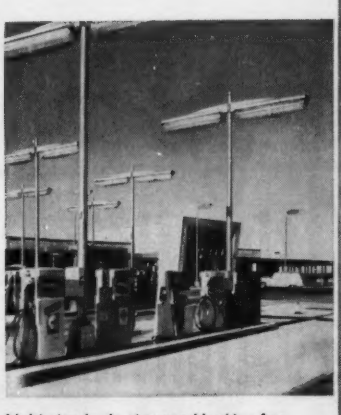
USS, COR-TEN, MAN-TEN and TRI-TEN are registered trademarks.

Watch United States Steel's special Christmas show, **The Coming of Christ**, in Color on NBC-TV, Wednesday, December 21, 8:30 P.M., E.S.T.

USS **United States Steel**

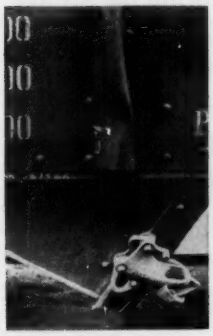


Cranes have to operate in all-weather temperatures and are subject to stress and shock. That's why many of them are made of tough TRI-TEN Steel.



Light standards stay good looking for years because of COR-TEN Steel's outstanding atmospheric corrosion resistance. Paint life is extended. Slim design is made possible by COR-TEN Steel's strength.

TRI-TEN Steel has cut weight and cost of dozens of major bridges. In the bridge shown here, TRI-TEN Steel saved a quarter of a million dollars.



One of the first applications of COR-TEN Steel was in hopper cars for weight reduction and longer life. Today, use of COR-TEN Steel can save hundreds of dollars over the life of a car.

MAN-TEN Steel, used in truck frames and body members, reduces dead weight and increases payload.

The LPG cylinder business uses considerable amounts of MAN-TEN Steel because of its strength, cost and ease of fabrication to lighten the weight.

This mark tells you a product is made of modern, dependable Steel.

Here's a book that is in the hands of thousands of engineers and designers. It is your guide to the design of lighter, stronger equipment and structures.

design manual for high strength steels

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Saved the Heil Co. $40 on every Dehydrator Unit

When Cyclo-Matic Dehydration Units were recently redesigned for greater flexibility in handling different kinds of materials, The Heil Co. engineers decided to incorporate separate motors to drive the main fan and cooling fan, the compressor pump, oil pump, and revolving drum, all of which had previously been driven from one motor.

With the greater number of drives involved, The Heil Co. engineers called in a Gates Representative to see if any savings were possible on drive costs through use of new Gates Super High Capacity V-Belt Drives. Here are the savings that were realized . . .

SAVED COST: On the original main drive alone, cost of conventional-type drive was $128.30. On the new main drive, Super HC High Capacity Drives cost only $88.26 — a saving of $40.04 on each main drive! While cost savings on auxiliary drives were not appreciable, additional benefits were reaped here through . . .

SPACE AND WEIGHT SAVINGS: Up to 62% saving in space, and as much as 32% saving in weight, have been realized over and over — not only by The Heil Co., but by hundreds of other manufacturers who have put Gates Super HC High Capacity V-Belt Drives on their products. You can do the same —just by contacting your Gates Representative.

AVAILABLE NATIONWIDE — Gates Super HC High Capacity V-Belt Drives are stocked in key industrial centers throughout the United States and Canada. You'll find your nearby Gates Representative listed in the Yellow Pages of your phone book. Ask him for your free copy of *The Modern Way To Design Multiple V-Belt Drives.*

The Gates Rubber Company, Denver, Colorado

Gates *World's Largest Maker of V-Belts*

Gates Super HC HIGH CAPACITY V-Belt Drives

same hp capacity in smaller package

TPA540

Circle 427 on Page 19

ELECTRONICS.... HYDRAULICS.... HEAT TRANSFER.... LUBRICATION

NUCLEONICS.... SONICS.... COOLANTS.... DIELECTRICS:

Monsanto Specialized Fluids and new FluiDesign Service can help you benefit from

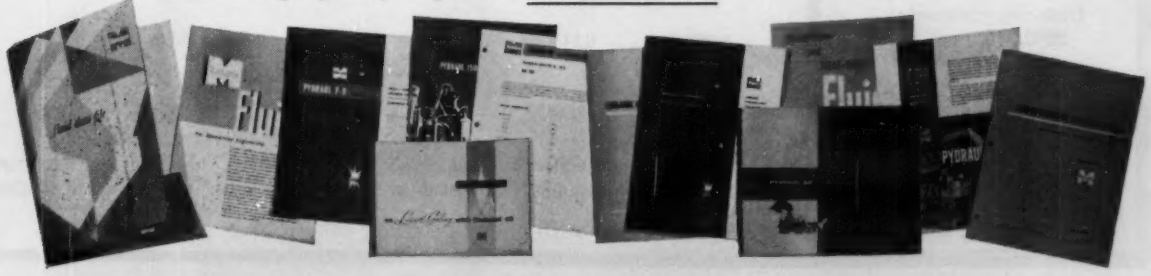
A RENAISSANCE IN ENGINEERING DESIGNS

Conventional fluids (water, oil) impose well-known restrictions on engineering designs. Heat, radiation, fire hazard, shear, electrical requirements, extreme pressure, friction—all cause problems—limit you in design flexibility, in imaginative thinking, in new ideas.

Monsanto's specialized synthetic fluids—chemically tailored to minimize many design restrictions in power transmission, lubrication, heat transfer, insulation, cooling—make new and improved designs practical. Spawned by advances in specialized fluid properties and broadening of fluid functions—a renaissance in engineering concepts is starting now. These specialized fluids open new design opportunities for your exploration.

Monsanto's new FluiDesign Service—established to help you meet your needs best from the capabilities of some thirty specialized fluids—can give you valuable guidance at the outset of your design exploration and engineering planning. For example, the next two pages provide you with the FluiDesign Service Report, "Fire-Resistant Fluids for New *Mechanical* Applications." Among the fifteen fluids described, one or more may allow you to engineer your next design for safer, more efficient performance.

Be sure to get your fact-packed Fluid Data File...



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From Monsanto FluiDesign Service . . .

FIRE-RESISTANT FLUIDS FOR NEW

The fifteen fire-resistant fluids described here are now at work in industrial and aircraft hydraulics, heat transfer and other mechanical applications which require a firesafe fluid. When you need a fire-resistant fluid for any application, one of these Monsanto specialized fluids may be adaptable to your job.

Consider how these and other specialized fluids might solve special-design engineering problems for you. If one of these fifteen does not meet your present requirements, Monsanto FluiDesign Service will make other recommendations for your application. Just send a brief description of the conditions which your fluid must meet.

For the specific properties you need, only Monsanto can make and help you select from so many kinds of specialized fluids, including

	Skydrol 7000	Skydrol 500A	Pydraul 60	Pydraul 150	Pydraul F-9	Pydraul A-200
Flash point, °F., Cleveland Open Cup	425°	360°	435°	380°	430°	380°
Fire point, °F., Cleveland Open Cup	475°	425°	460°	470°	675°	680°
Autoignition temp., °F.	1050°	>1100°	>1000°	>1100°	>1100°	>1200°
Viscosity, cs. 100°F.	15.5	11.5	11.1	30.8	47	49.5
210°F.	4.00	3.92	2.65	8.0	5.5	4.8
Pour point, °F.	< −70°	< −85°	−70°	−55°	−5°	10°
Boiling point, °F. 760 mm. Hg	709°	—	707°	617°	644°	620°
Max. bulk temp., °F. long term	200°	225°	200°	200°	300°	300°
Coefficient of thermal expansion, per °F.	0.00042	0.00045	—	0.00042	0.00041	0.00040
Specific heat, 25°C.	0.42	0.38	0.42	0.40	0.32	0.28
Thermal conductivity Btu/hr./ft.^{2}/ft./°F.	0.0723	0.0777	0.047	0.070	0.067	0.059
Bulk modulus, psi	328,000	308,000	328,000	319,000	387,000	400,000
Specific gravity, 25°/25°C.	1.08	1.07	1.09	1.13	1.28	1.42
Resistivity, ohm-cm, 25°C.	5×10^8	4×10^7	—	—	1.5×10^9	3.3×10^{10}
Dielectric strength, 25°C., 60 cps., 0.1 in.	36KV	12KV	—	—	33KV	38KV
Dielectric constant, 25°C., 1000 cps.	8.87	8.81	—	—	6.25	—
Power factor, % 1000 cps., 25°C.	0.49	—	—	—	2.2	—
Original use	aircraft hydraulics	aircraft hydraulics	industrial hydraulics	industrial hydraulics	industrial hydraulics	industrial hydraulics

MECHANICAL APPLICATIONS

phosphate esters, silicate esters, diphenyl and terphenyl and chlorinated derivatives. Monsanto has the best facilities and broadest know-how for making the widest variety of fluid "base" stocks and additive modifiers of any chemical manufacturer. Whatever your requirements, consult Monsanto if you need a fluid for a new product or machine-design concept.

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Pydraul 625	Pydraul AC	OS-81	Aroclor 1221	Aroclor 1232	Aroclor 1242	Aroclor 1248	Aroclor 1254	Transformer Askarel
465°	420°	—	295°	308°	360°	379°	—	460°
745°	650°	—	349°	460°	>610°	>640°	>660°	460°
>1100°	1100°	1100°	>1000°	>1100°	>1200°	>1200°	>1200°	1000°
135	88.2	35.25	4.6	6.9	17.2	45.3	500	5.0
6.1	5.15	3.18	1.2	<1.8	2.5	3.2	6.14	1.5
20°	20°	15°	34°	−32°	2°	20°	50°	47°
724°	688°	—	527°	554°	617°	644°	689°	460°
300°	300°	300°	600°	600°	600°	600°	600°	600°
—	0.00040	—	0.00039	0.00040	0.00038	0.00039	0.00037	0.00039
—	—	0.31	0.33	0.31	0.29	0.27	0.26	0.25
0.065	—	—	0.067	0.063	0.058	0.057	0.054	0.050
375,000	375,000	—	—	—	—	428,000	—	—
1.36	1.35	1.40	1.18	1.26	1.38	1.45	1.54	1.57
—	—	—	1×10^{12}	1×10^{12}	1×10^{12}	1×10^{12}	1×10^{12}	5×10^{11}
—	—	—	>35KV	>35KV	>35KV	>35KV	>35KV	35KV
—	—	—	4.5	5.4	5.8	5.6	5.0	4.0
—	—	—	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
industrial hydraulics	air-compressor lubrication	turbine and compressor lubricant	plasticizer	plasticizer	capacitor impregnant; heat transfer	heat transfer	capacitor impregnant	transformer dielectric

Circle 428 on Page 19

NEW
CUNO
MICRO-WYND
FILTER CARTRIDGE
PART NUMBER
ACFC

You asked for a wound filter cartridge with superior performance characteristics . . . and here it is!

MICRO-WYND

. . . the outstanding depth-type, disposable filter cartridge

MICRO-WYND is Cuno's answer to the many operating headaches typical of the ordinary wound cartridge . . . because it is designed and built with absolute control of all elements affecting filtration performance.

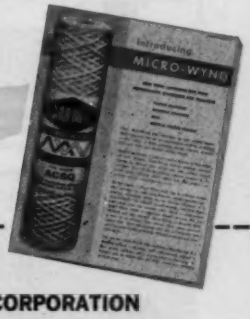
MICRO-WYND's patented manufacturing process unites a layer of fibers of proven filter properties with a winding yarn of exceptional strength. The filter fibers, woven in and out of the winding yarn, are firmly locked in place, completely bridging each diamond-shaped fluid path. This exclusive Cuno process does away with problems of variable flow, early loading, sudden contaminant bypassing that users encounter with ordinary wound filters whose efficiency is compromised by a mere brushing of the winding yarn to raise filter fibers.

There's more to MICRO-WYND, too, than meets the eye. Graded density in depth, or ability to trap progressively finer particles from O.D. to core, is achieved by controlled dispersion of the separately applied layer of filter fibers. Strict control of winding yarn tension and method of application also gives you a cartridge that is structurally strong, that assembles in multiples without extra end sealing devices, and that stands up under the toughest operating conditions.

Get the facts *now* on MICRO-WYND . . . the all-new wound cartridge that's designed and built to set new filtration performance standards in your plant!

Send Today

FOR COMPLETE DATA



CUNO®

THE CUNO ENGINEERING CORPORATION

MERIDEN, CONNECTICUT

IN CANADA: PEACOCK BROS., LTD.
MONTREAL, P.Q.

THE CUNO ENGINEERING CORPORATION
Dept. 19, 80 South Vine Street
Meriden, Connecticut

Please send me new Data Folder—MW-100—on Micro-Wynd. The fluid I want to filter is_____

Name_____

Title_____

Company_____

Street_____

City_____ Zone____ State_____

Circle 429 on Page 19

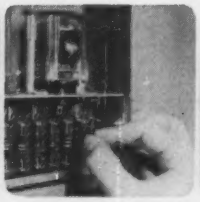
Plug-in components for electronic systems

Alden plug-in components offer far more than the convenience and ease of modular packaging . . . the prime advantage of these basic building blocks is that they make possible **more reliability in service.**

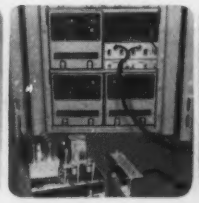
More in-service reliability through:

Tell-tale monitoring — all controls easily accessible, up front. Tiny tell-tales spot trouble instantly, isolate it to a specific modular unit.

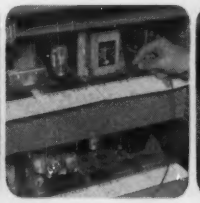
Quick removal — malfunctioning unit can be removed with a half turn of the wrist, reducing down-time to 30 seconds with plug-in spare.



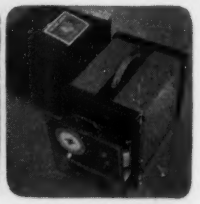
Quick replacement — malfunctioning component can be snapped out and replaced in seconds.



In-service checks — Alden Adapter Cable brings chassis out into the open while in operation for quick checking.



Single point of check — all leads brought to single checkpoint — makes possible color coded, vividly illustrated circuit legends.

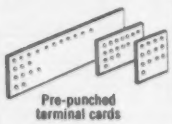


Quick repair — rugged, portable carrying case protects chassis. Replacement of malfunctioning chassis is only air mail time away from service center.

From layout to finished equipment...in just 3 steps:

1

Unitize circuitry in compact, vertical planes with Alden Terminal Card Mounting System — Your circuitry is assembled in complete units, ready for housing.

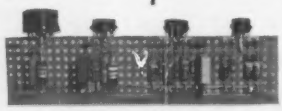


Pre-punched terminal cards

Miniature terminals

Jumper strip (eliminates wiring)

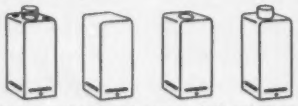
Card mounting sockets



Complete circuits ready for plug-in package or chassis

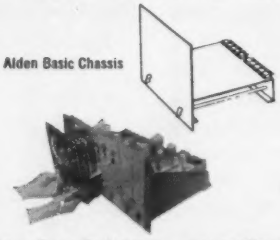
2

Mount cards in Alden Basic Chassis for tremendous variety with standard components — Alden provides standard plug-in or slide housings. With spares, units are replaceable in 30 seconds.



Alden plug-in package 4 sizes: 7, 9, 11, and 20 pin

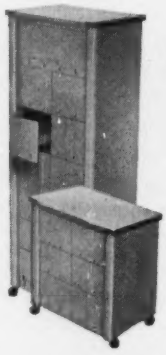
Alden Basic Chassis



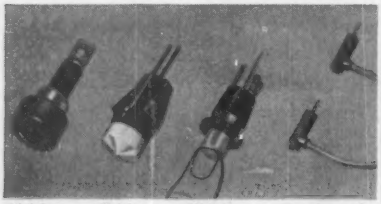
Picture Frame Rack Adaptor — for mounting Alden Basic Chassis in any combination. Mounts in standard rack or Alden UniRacks.

3

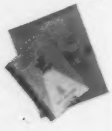
Mount sub-assemblies in Alden UniRacks — UniRacks fully utilize all the features of plug-in construction, give you a more compact, serviceable unit. Furnished in 2 basic heights, either mobile or stationary — easily accessible, front or rear.



Assign Alden testing and sensing elements to each unit to spot trouble instantly

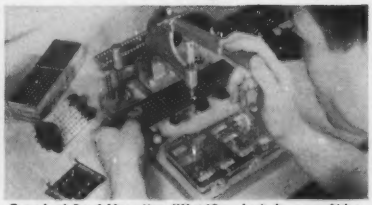


Miniature test jacks | Miniature indicator lights | Miniature Pan-i-lite Switch (momentary contact) | Stacking and patch cord

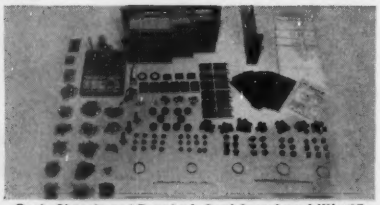


Write today for new Alden Plug-in Booklet and handy, up-dated Quick Order Guide.

Two time saving, money saving, "GET STARTED" KITS



Terminal Card Mounting Kit #42 — Includes new Alden Staking Tool plus prepunched terminal cards, ratchet terminals, eyelets, brackets, and card mounting tube sockets —everything for simplified, time saving circuitry layout. **$49.95**



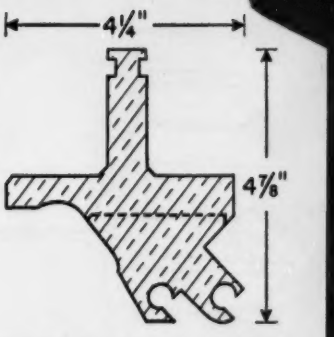
Basic Chassis and Terminal Card Assortment Kit #37 — All necessary components to mount, house, fasten and monitor your electronic circuitry. Makes sense, save time, establishes reliability. **$249.50**

Other kits from **$11.50**

ALDEN

PRODUCTS COMPANY, 12114 N. Main Street, Bockton, Mass.

AGAIN-



DOTTED LINE SHOWS where two copper extrusions were brazed together to make original part. When you consider the intricate shape and the weight of the part (a 3⅞" section measuring 4¼" x 4⅞", weighing 8 lbs. 7 ozs.), you can readily understand why it was at first thought impractical to make it into a single extrusion.

Revere helps "fit the metal to the job"

AND ONE COPPER EXTRUSION REPLACES TWO, SAVING TIME AND MONEY WITH CONSIDERABLE INCREASE IN LIFE OF PART

The Revere Copper Extrusion shown above was originally two extrusions brazed together. And, since it is quite an intricate shape, and weighty, it was at first thought impractical to make as a single extrusion, but the possibility was believed to be worth investigating.

Through close collaboration between the manufacturer's engineering department and the Revere Methods and Production Departments, it was found possible to combine these two sections into a single extrusion. Work was started, dies were made and test runs conducted. The tooling (for hot extrusion was followed by cold drawing) posed special problems. It had to be both rugged and precise in order to produce this monster to the manufacturer's exacting specifications. Finally, a sample extrusion was delivered to the customer for testing and found to be right in every way.

Not only does this new, single extrusion eliminate a great deal of machining but obviates the necessity of purchasing two separate extrusions and brazing them together. This means substantial savings in dollars and time involved, plus a longer-lasting part, because the heat required to join the two pieces originally used, tended to soften the built-up unit, thus shortening its useful life.

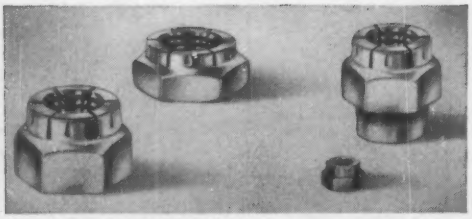
So, before you give up on what at first may seem an insoluble problem, why not call in Revere's Technical Advisory Service? It's entirely possible they can help you "fit the metal to the job" with a resultant saving in the production of a superior product.

REVERE
COPPER AND BRASS INCORPORATED
Founded by Paul Revere in 1801
230 Park Avenue, New York 17, N. Y.
Sales Offices in Principal Cities. Mills: Rome, N. Y.; Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles, Riverside and Santa Ana, Calif.; New Bedford and Plymouth, Mass.; Brooklyn, N. Y.; Newport, Ark.; Ft. Calhoun, Neb.
Distributors Everywhere.

Circle 431 on Page 19

Self-locking nut that locks without seating,

FLEXLOC



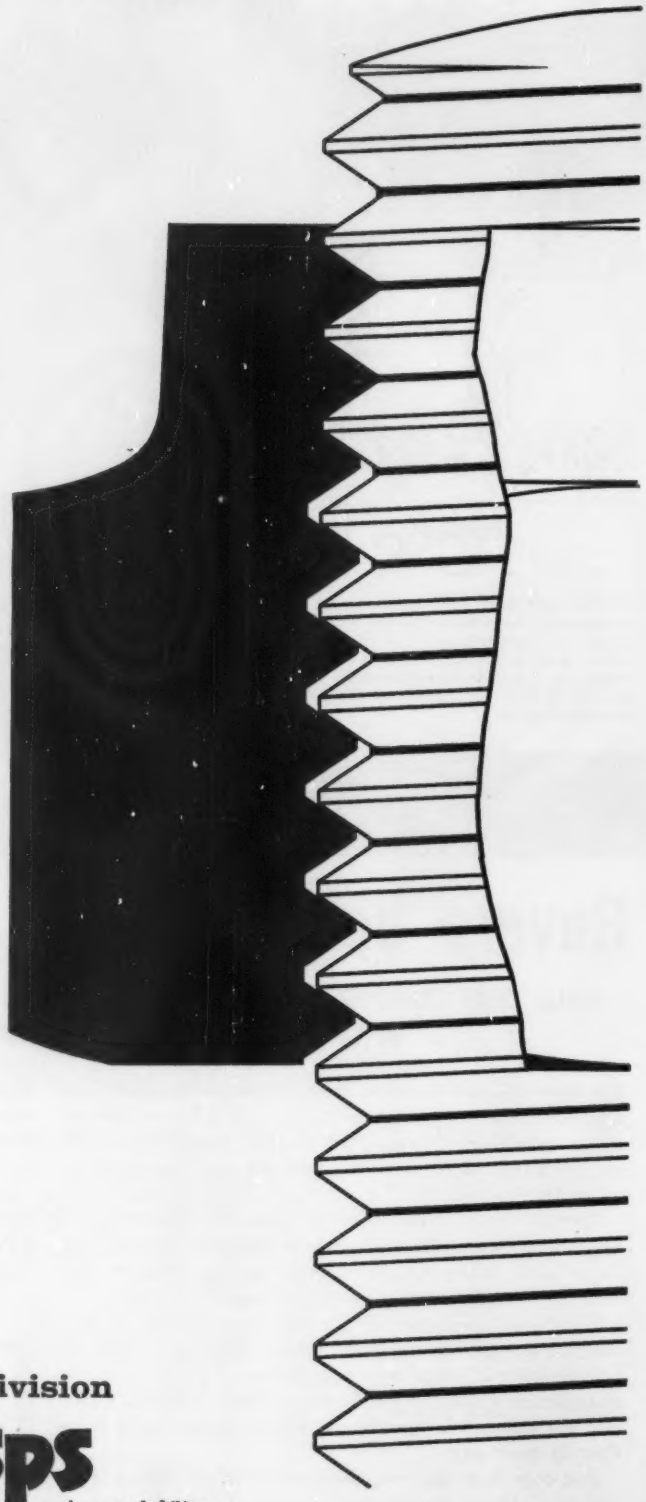
Left to right: full height, thin, microsize, clinch nut.

Three of the most significant features of 1-piece all-metal FLEXLOCs: they are self-locking; they lock without seating; they won't work loose, regardless of vibration.

With FLEXLOC no lockwashers, jam nuts, cotter pins or other auxiliary locking devices are needed. There's nothing extra to put together, come apart or get lost. Your design problem is simplified. Assembly time and costs are reduced. And maintenance expenses are lowered because FLEXLOCs can be readily removed and repeatedly re-used.

What's more, since FLEXLOCs lock without seating, they serve as stop nuts, staying put anywhere on bolt or stud once 1½ threads of bolt are past top of FLEXLOC. And there's no need to worry about the effect of "shake, rattle or rock" on FLEXLOCs. They just won't budge, even in the face of terrific impact, ceaseless vibration.

FLEXLOC Clinch Nuts—Designed for use in thin-section materials, they make blind fastening easy, are ideal where dismantling and reassembly is required. They are simply clinched into the material to be assembled and become an integral part of it. Use FLEXLOC Clinch Nuts in place of anchor, weld or cage nuts.



See your authorized SPS distributor for complete information on sizes, materials and finishes. Or write SPS—manufacturer of precision threaded fasteners and allied products in many metals, including titanium.

FLEXLOC Nuts

PRODUCT	SIZES
Full Height	#2 through 2"
Thin Type	#6 through 1½"
Microsize	#0 through #4
Clinch—regular	#4 through 5/16"
Clinch—microsize	#0 through #4

Regular clinch nuts come in 7 shank lengths, microsize clinch nuts in 2

INDUSTRIAL FASTENER Division

JENKINTOWN 18, PENNSYLVANIA

SPS

where reliability replaces probability

Circle 432 on Page 19

Quick delivery of the Drive you need!

Typical final assembly
of A-S Drives from completed sub-assemblies

When you purchase a Square D A-S Drive, you get a complete "package"—including drive motor, operator's station and all controls. You also get these important advantages:

QUICK DELIVERY • Square D's unique method of stocking sub-assemblies means quicker deliveries of packaged drives to meet your requirements.

EASY INSTALLATION • Maintenance manuals are complete in every detail, including step-by-step installation instructions. Moreover, each **A-S Drive** is completely factory-tested and adjusted when shipped — only a few trimming adjustments are needed to put it in operation.

MINIMUM MAINTENANCE • Industrially rated components are used throughout, and extra-sturdy cabinets give lasting protection. Static elements and encapsulated circuits—which are virtually maintenance-free — are utilized wherever possible.

EXTRA SAFETY • Only push buttons with heavy-duty construction and potentiometers with industrial clearances are used in operator's stations, for maximum personnel safety.

WIDE VARIETY AVAILABLE • There's a Square D "package" for *any* adjustable-speed job. You can choose from electronic, magnetic amplifier or motor-generator types — with ratings from 1/20 to 400 hp — and with accuracies to within fractions of 1%.

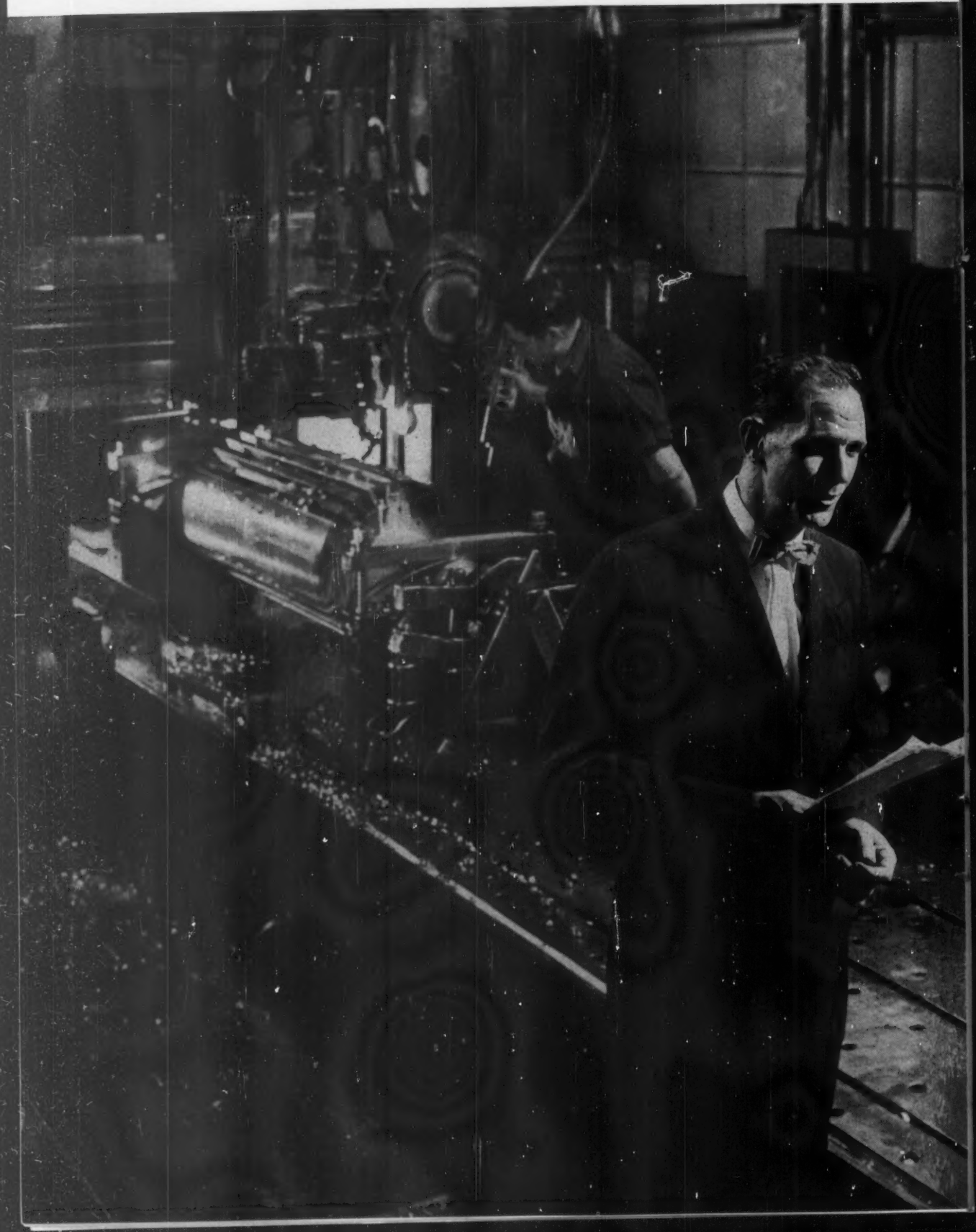
FIELD APPLICATION HELP • Square D has wide experience in the design and manufacture of adjustable-speed drives, and field specialists are trained to help you in the selection of the proper drive.

Write FOR BULLETIN • *Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin*

SQUARE D COMPANY

wherever electricity is distributed and controlled

THE MAN & THE DRIVES



FROM WESTINGHOUSE

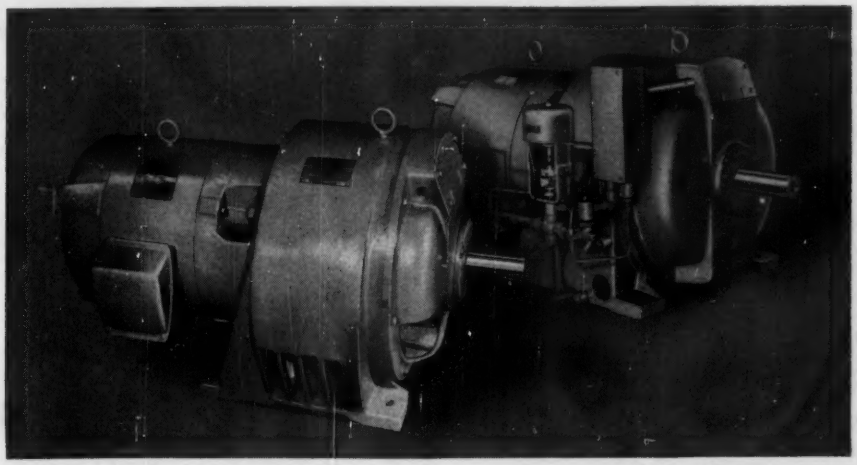
Mr. Westinghouse and MagnaFlow Drives Bring Simple Solution to Speed Control Problems, Save Money and Space, Too!

Westinghouse MagnaFlow* electromagnetic drives—air or liquid cooled—provide infinitely adjustable speeds from standstill to top speed with regulation guaranteed at $\pm 2\%$ of top speed over a 17-to-1 speed range (even closer regulation when desired). Control is smooth and stepless.

These compact drives, having a minimum number of parts, are built for rough, trouble-free service. The unique electromagnetic coupling maintains adjustable output speed without the use of pulleys, belts, brushes, commutators, slip rings or rotating windings. A rugged Life-Line® "A" motor supplies reliable a-c drive power. No power converting equipment needed—only a small, static exciter and an operator's control station. Initial cost is low; installation—easy and inexpensive.

Your Man from Westinghouse is ready now to help you apply MagnaFlow drives . . . and any other drives you may need. Call him . . . or write for a copy of Westinghouse MagnaFlow Electromagnetic Drives (B-7875), Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania. You can be sure . . . if it's Westinghouse. J-22162

*Trade-Mark



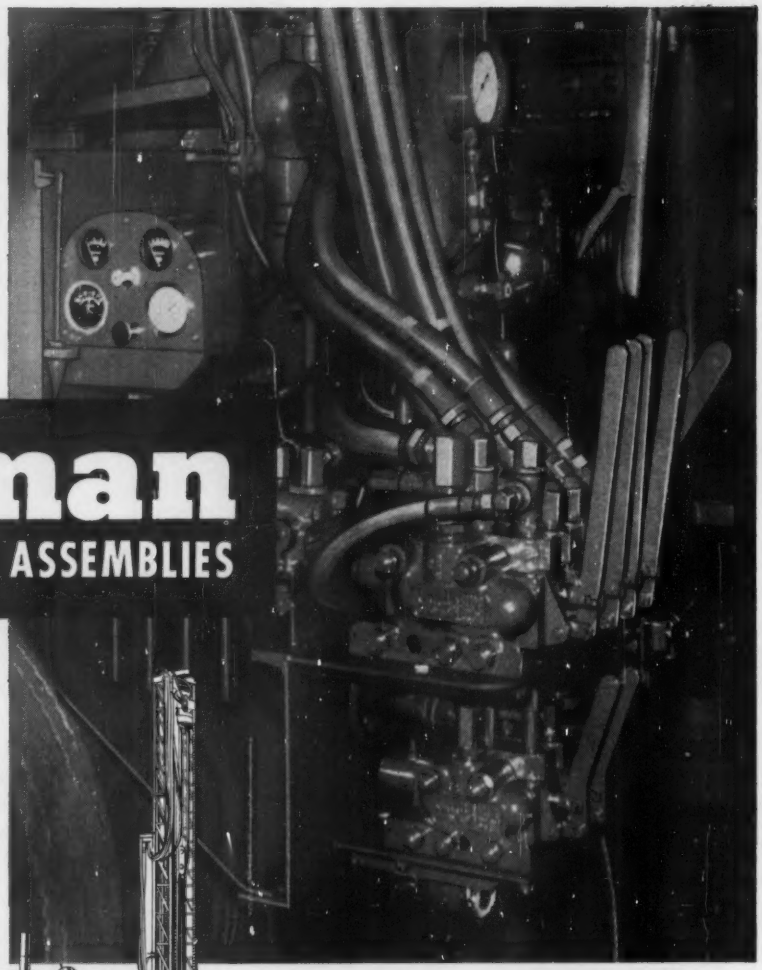
MagnaFlow drives—air cooled (foreground) and liquid cooled—are available in various horsepower ratings for winders, conveyors, fans, pumps, extruders and other machinery in all industries.

Westinghouse

Circle 434 on Page 19

THE KEY TO A DEPENDABLE SYSTEM!

Eastman
HYDRAULIC HOSE ASSEMBLIES



EASTMAN designs complete hydraulic operation for SCHRAMM Rotadrill

Valves mounted in three convenient banks for each outrigger, forward and reverse rotation of motor, slow down speed, rapid down speed and for breakout cylinder.

The cooperation of EASTMAN Engineering was enlisted in making the operation of this truck-mounted Schramm Rotadrill *completely hydraulic.*

Hydraulic power is delivered through EASTMAN Hydraulic Hose Assemblies to:

1. Three-Speed Reversible Rotation Head: Standard speeds—44, 65 and 120 r.p.m. with 26,500 inch pounds torque. 2. Cylinders controlling down feed, rapid feed and slow feed. 3. Controls for raising and lowering of mast. 4. Breakout Cylinder. 5. Hydraulic Winch and Hook. 6. Three Outriggers.

Dependable field service is assured through EASTMAN Two-Wire Braid High Pressure Hose with Permanently Attached Couplings providing a bond stronger than the hose itself.

Efficient power delivery through the extensive, multiple circuits of this rock-drilling rig is obtained through EASTMAN designed permanently attached hose assemblies which insure longer life and lower cost.

PERMANENTLY ATTACHED COUPLINGS
for 1, 2, and 3 wire braid rubber cover hose

REUSABLE COUPLINGS
for fabric cover hose

REUSABLE COUPLINGS
for rubber cover hose

CLAMP COUPLINGS
for 1, 2, and 3 wire braid rubber cover hose

ENGINEERED FOR ENGINEERS BY ENGINEERS

Let EASTMAN Engineering assist you in planning the initial layout of your hydraulic system—for most efficient power delivery and lowest cost.

Write today for Bulletin 100 and 200 on EASTMAN High, Medium and Low Pressure Hydraulic Hose Assemblies.

Eastman MANUFACTURING COMPANY
Dept. MD-12, MANITOWOC, WISCONSIN

Circle 435 on Page 19

Photo courtesy of The Maytag Company

BETTER CASTINGS AT MAYTAG ATTRIBUTED TO ACHESON MOLD COATING PROPERTIES

Consistently uniform castings of gear housings for their entire line of automatic washers, have been achieved at The Maytag Company by the use of 'dag' 193 as a refractory mold coating. In their Newton, Iowa foundry, up to 2500 sets of gear housings and housing covers are produced in a three-shift work day. Since these aluminum housings have been designed to provide maintenance-free service over the lifetime of the washer, they receive permanent lubrication at the time of assembly. The protection of the gear train rests on the tightness of the housing . . . its ability to keep lubricant supply in, detergents and other contaminants out.

Uniformity was not easily achieved. The design of the housing and cover castings made it difficult to produce a part which was entirely free from shrinkage and surface defects. Wall thickness varies between ¼" and ¾". Hot work tool steel, S.A.E. H-13, a non-heat treated alloy, was determined to be the best material for these permanent mold dies. The dies are pre-heated before applying the Acheson coating material. 'dag' 193 is diluted 1 to 3 with water for this application. It is sprayed on the mold surfaces during each shift with normal commercial equipment at line air pressure. During molding operations the dies are held at approximately 700°F., controlled with air and water. Pouring temperatures range from 1175°F to 1200°F. Sample castings are removed from the line periodically and checked for pressure tightness. Where additional protection is indicated, a touch-up coating is applied.

Because of its excellent insulating properties, 'dag' 193 minimizes shrinkage. The flow of molten aluminum and the degree of cooling is better controlled, even in those areas where the casting shape varies from thick to narrow. The continuous film of insulating particles spreads uniformly over the entire die surface, reaching critical areas to provide equalized insulation for all parts of the casting. Sound, trouble-free parts are the result at Maytag. Ease of parting is illustrated by the fact that the original H-13 steel die is still on the line after four years of use. Look into the application of a quality Acheson Dispersion in your permanent molding or casting operation. Send for Bulletin 425.

Product Design Aided By Acheson Dry-Film Lubricants

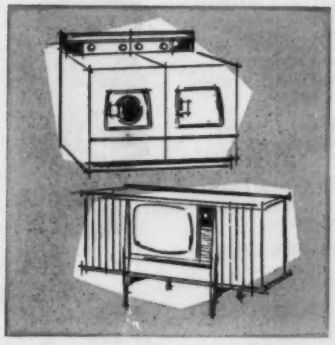
The continuing search for improved methods of designing and producing profitable — yet "abuse proof" appliances, has led a growing number of manufacturers to Acheson dry-film lubricants. Two of the most popular of these products are 'dag' Dispersions 154 and 210.

'dag' 154 is a dispersion of colloidal graphite in isopropyl alcohol. This versatile material combines the fast air-drying quality of its volatile carrier, with the many inherent properties of colloidal graphite. These include low friction, long wear life, chemical inertness, and electrical and thermal conductivity properties. Because of its unique features, 'dag' 154 is providing permanent lubrication for internal mechanisms of toasters, washers, dryers, and other electrical appliances.

A companion product, 'dag' 210, is a dispersion of colloidal molybdenum disulfide in isopropyl alcohol. When diluted with compatible diluents, it may be applied by a variety of methods to form a quick-drying, tightly adherent MoS_2 film. This film exhibits the unique, high-pressure, high-temperature, lubricating and release properties inherent with molybdenum disulfide.

One of the most recent innovations has been the development of EMRALON® dispersions of tetrafluoroethylene (TFE) in resin carriers. This permits, for the first time, the application of this unique polymer to a wide variety of heat sensitive substrates. The extremely low friction coefficient of TFE makes 'EMRALON' ideally suited for light load mechanisms.

There are many other applications of Acheson Dispersions in the appliance industry; one or more should prove profitable for you. For further information, write for our current Products List. Address Dept. MD-12.



'dag' and 'EMRALON', are trademarks registered in the U. S. Patent Office by Acheson Industries, Inc.

ACHESON

dispersions digest reporting uses for

dag® BRAND DISPERSIONS

ACHESON **Colloids Company** PORT HURON, MICHIGAN

A division of Acheson Industries, Inc. Also Acheson Industries (Europe) Ltd. and affiliates, London, England

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EAstbrook 7391 & 2

GRAND RAPIDS, MICH.
William H. Nash Co., Inc.
GL 2-0929

HARTFORD, CONN.
Pearse-Pearson Co., Inc.
Broomfield, Conn.
CHapel 2-7777

HONOLULU 13, HAWAII
Chapson Bros., Ltd.
57-306

HOUSTON 11, TEXAS
Leo J. Schindler Co., Inc.
WAlnut 3-2525

HUNTINGTON, W. VA.
K. C. Mosier Co.
JAckson 5-4831

INDIANAPOLIS 2, IND.
Neff Engineering Co.
WAlnut 5-5311

KANSAS CITY 15, KAN.
Air Equip. Co.
DRexel 1-3709

LOS ANGELES, CALIF.
The Teglen Eng. Co., Inc.
So. Pasadena, Calif.
MUrray 2-2856

LOUISVILLE, KY.
Charles Weber Co.
MElrose 7-2574

MILWAUKEE 8, WIS.
C. L. Thompson Co.
HIlltop 4-4817

MINNEAPOLIS 4, MINN.
H. U. Rogness
FEderal 3-5595

MOLINE, ILL.
Walter Norris Eng., Co.
764-1196

NEEDHAM, MASS.
Pearse-Pearson Co., Inc.
HIlicrest 4-1090

NEWARK, N. J.
K. E. Knotts Co.
Westfield, N. J.
ADams 2-8700

NEW YORK, N.Y.
K. E. Knotts Co.
BArclay 7-7455

OKLAHOMA CITY, OKLA.
Nix Supply Co.
ORange 7-6623

PHILADELPHIA, PA.
J. A. Moody Co.
Wayne, Pa.
MUrray 8-3750

PHOENIX, ARIZ.
Air-Draulics Co.
ALpine 8-6441

PITTSBURGH 26, PA.
Leonard R. Nourie, Inc.
LOcust 1-1628

PORTLAND 9, ORE.
Power Transmission Products
CA 7-1272

PROVIDENCE, R. I.
Pearse-Pearson Co., Inc.
GAspee 1-2557

RICHMOND 20, VA.
C. Arthur Weaver Co., Inc.
ELgin 9-5771

ROCHESTER 18, N. Y.
Goll-Hanford Corp.
GReenfield 3-8323

ROCKFORD, ILL.
Walter Norris Eng. Co.
WOodland 3-2811

SAN FRANCISCO, CALIF.
Airdraulic Ind. Products Co.
Burlingame, Calif.
Diamond 2-7297

SEATTLE 9, WASH.
George W. Warden Co.
ATwater 3-0622

SHREVEPORT, LA.
Harris Frederic & Co., Inc.
5-7455 & 5-7456

ST. LOUIS 10, MO.
Sturgis Equip. Co.
OLive 2-5380

STRATFORD, CONN.
Pearse-Pearson Co., Inc.
DRexel 8-2992

SYRACUSE 3, N. Y.
Ralph W. Earl Co.
GRanite 5-5145

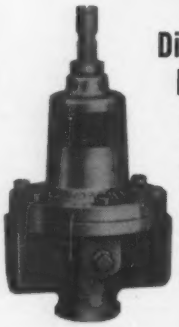
TULSA, OKLA.
Nix Supply Co.
Diamond 3-8916

VANCOUVER, B. C.
Galbraith & Sulley, Ltd.
CHerry 5121

LACHINE-MONTREAL, QUE.
Cowper Co., Ltd.
MElrose 7-6746

TORONTO, ONT.
John Spotton Co., Ltd.
CLifford 9-8276

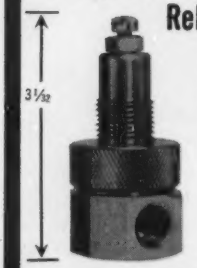
Norgren Diaphragm-Type Relief Valves and Flow-Control Valves



Diaphragm-Type Relief Valve

Type 62AX— for use with air, water, oil and similar fluids. ⅛", ¼", ⅜", ½", ¾", 1" pipe sizes. For relief pressures up to 250 psig (¼", ⅜", ½") and up to 125 psig (¾", 1").

Compact Diaphragm-Type Relief Valve



Type 40AB— for use with air, water, oil and similar fluids. ⅛", ¼" pipe sizes. Relief pressure adjustable up to 100 psig.

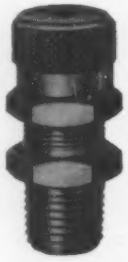
Pop Safety Valves

Type 1000— for air. ⅛", ¼", ⅜", ½" pipe sizes. Relief pressure ranges: 25 to 200 psig.

Flow Control Valves

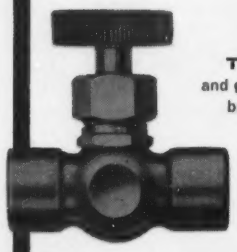
Types 1100 and 1200— for air, oil, hot and cold water, steam, non-corrosive gases and liquids. Two-way and single-way valves. ¼", ⅜", ½" pipe sizes. Max. pressure: 250 psig on air and hydraulic systems, 125 psig on saturated steam and hot water systems.

Low Flow Relief Valves



Type 61A— for air, water and non-corrosive gases. ⅛", ¼" pipe sizes. For relief pressures: 25 to 300 psig.

Needle Valves

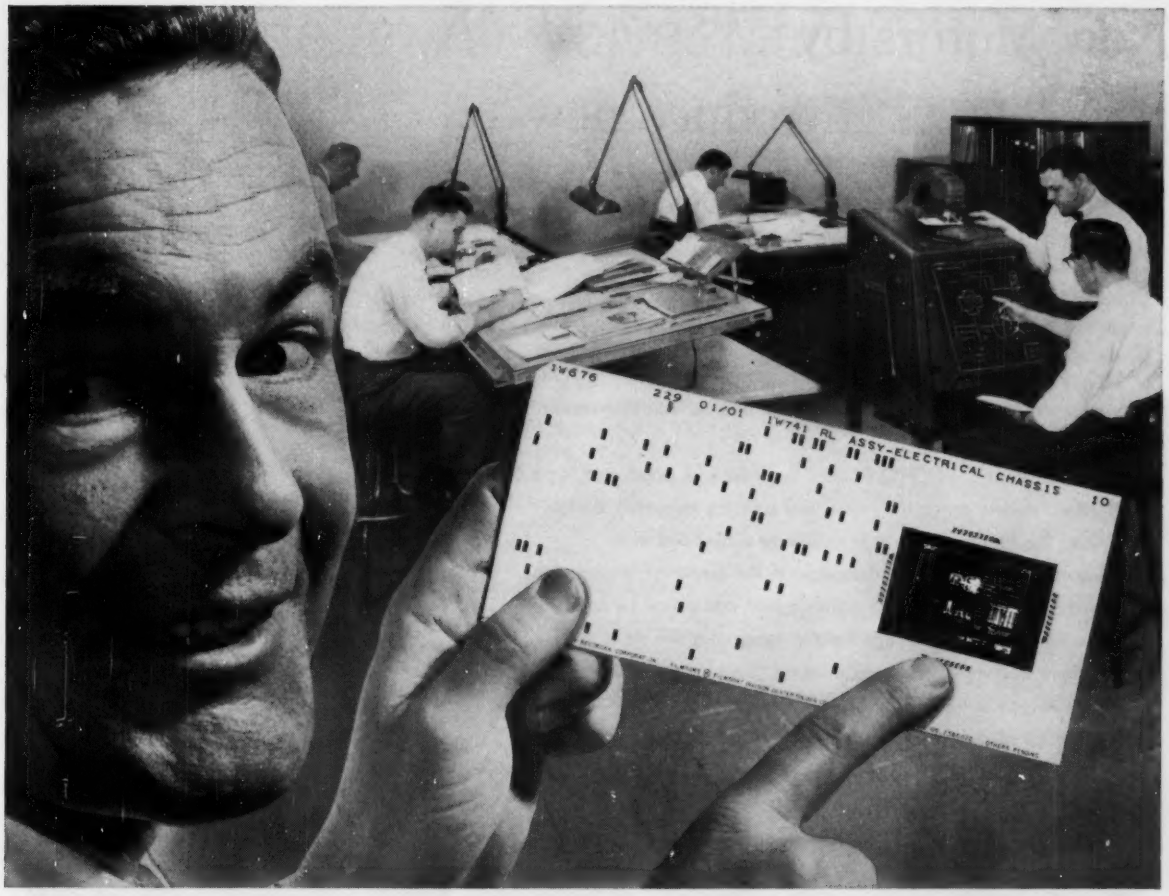


Type N— for air, liquids and gases that do not affect brass. ⅛", ¼" pipe sizes. Maximum pressure: 250 psig.

For complete information on these products or the complete Norgren line of compressed air filters, pressure regulators and lubricators, call your nearby Norgren representative, listed at left—or write for descriptive literature.

C. A. NORGREN CO. FOUNDED IN 1926

3442 SOUTH ELATI STREET • ENGLEWOOD, COLORADO



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Recordak Precision Microfilming gives you better than 120 lines per mm resolution at 30 to 1 reduction ratio.

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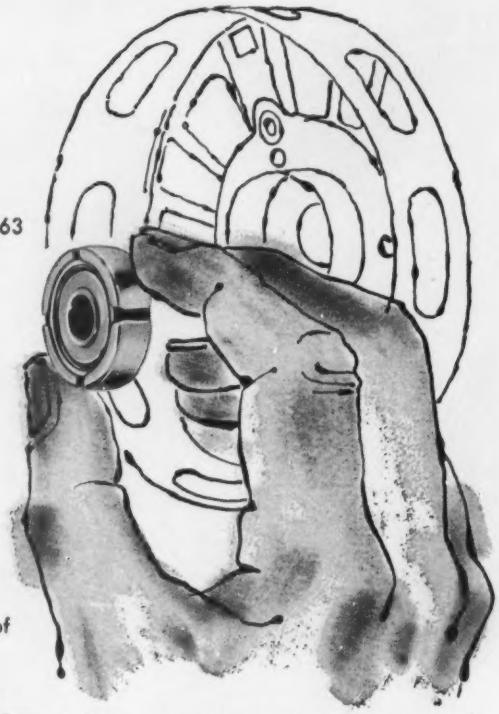
Circle 438 on Page 19

New Motors by **UNIVERSAL** introduce new free-aligning ball bearing assembly*

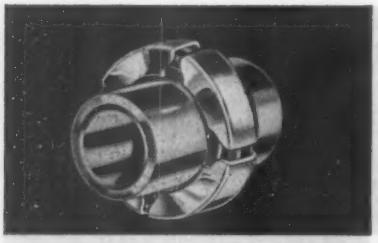
. . . utilizing only the shaft for alignment, the new Universal Ball Bearing Assembly provides:
. . . reduced noise level in ball bearing motors . . .
. . . easier starting regardless of load . . .
. . . elimination of pre-loaded bearings due to misalignment.



Two new UNIVERSAL ELECTRIC motors, Type 523 (4 pole) and Type 563 (6 pole) incorporate an entirely new ball bearing assembly design. The new ball bearing assembly is resiliently suspended in a neoprene collar with the axis of support in the center of the bearing. The bearing is thus inherently in balance and can adjust to any shaft misalignment 100% of the time utilizing only the shaft itself for alignment. This new design requires no pressure to retain the bearing in its position and the bearing cannot be forced from its seat regardless of the amount or type of load placed on the shaft.

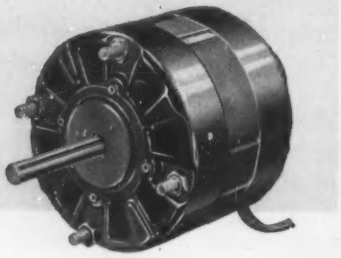
Advantages of the UNIVERSAL ELECTRIC ball bearing design are (1) reduced noise level, (2) permanent cushioned end play, (3) easier starting, (4) elimination of snap rings, shoulders and undercuts thus providing a stronger motor shaft and (5) elimination of preloaded bearings due to misalignment thus resulting in a free running motor with a longer motor life. UNIVERSAL offers the only ball bearing shaded pole motors on the market that can make all of these claims.

*Pat. applied for



Universal Bearings*

Universal Free-Aligning sleeve-type Bearings eliminate fractional HP motor bearing problems due to misalignment. Like the new ball bearing assembly, this revolutionary bearing is inherently in balance and can adjust to any shaft misalignment 100% of the time under any load condition.



UNIVERSAL Electric Motors type 523 and type 563 with the new ball bearing assembly, offer the perfect flat speed torque curve necessary for critical air moving or recorder applications. In addition to these 2 new motors, UNIVERSAL ELECTRIC also is making a new 6 pole sleeve bearing motor Type 63 as well as the standard 4 pole, Type 23. These motors offer maximum performance and efficiency for kitchen ventilators, unit heaters, evaporative coolers, condenser fans, refrigerated cabinets, etc.

Write for complete specifications on your requirements.

55

UNIVERSAL ELECTRIC COMPANY

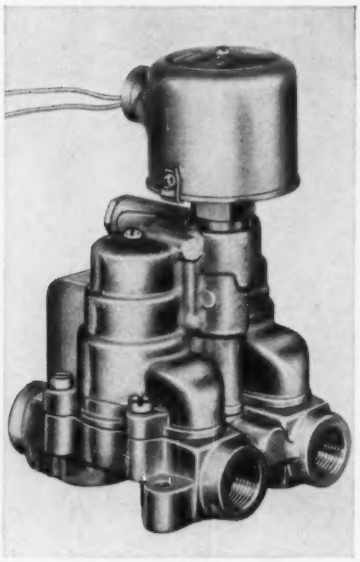
PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 10

Circle 439 on Page 19

Why Name an Air Valve "Mach 2"?

"Mach 2" is the name of a new Crescent® Air Valve now ready for distribution to industry. An identifying name is desirable for this valve to point up the new kind of performance it brings to air control and to distinguish it from the other valves in the long-established Crescent® line.



The new Crescent "Mach 2" 4-Way Valve. (Half-inch pipe size shown.)

A Breakthrough in Cycling Speed

Actually these Crescent® "Mach 2" 3-Way and 4-Way Air Valves represent a breakthrough, as the name suggests. For years a cycling speed of 600 to 700 cycles a minute seemed to be the limit for solenoid pilot valves. The original Crescent 4-Way Valves attained that speed a long time before other valves even approached it. Now, the "Mach 2" has been tested and rated for 1000 cycles per minute continuous duty. During a two-hour test at a speed of over 1500 cycles per minute the coil temperature stabilized at 7°C below the maximum code limit for class A coils. Cycling speeds as high as 2100 have been successfully reached for intermittent periods of 20 minutes.

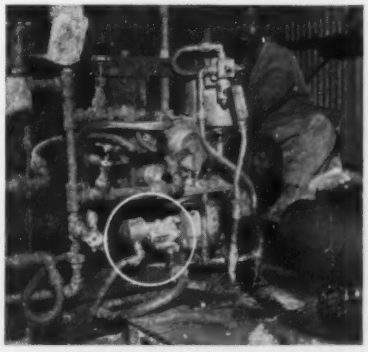
Brings New Dependability

We realize that such high cycling speeds are seldom needed. However, speed and endurance seem to be Siamese twins. Here's why: (1) Speed depends on an extremely short stroke of the solenoid plunger (3/32 of an inch—approximately the thickness of a nickel—in the new "Mach 2"). This greatly reduces coil heating and, as heat goes down, coil life expectancy goes up. (2) High cycling speeds demand a drastic reduction of friction in the solenoid and pilot valve section. In the "Mach 2" pilot valve, a tiny ball seats on "O" rings at both ends of a pilot cartridge. The ball moves freely, independent of the seals. There is no "O" ring drag on the pilot plunger because it requires no seals; where there is no friction there can be no wear.

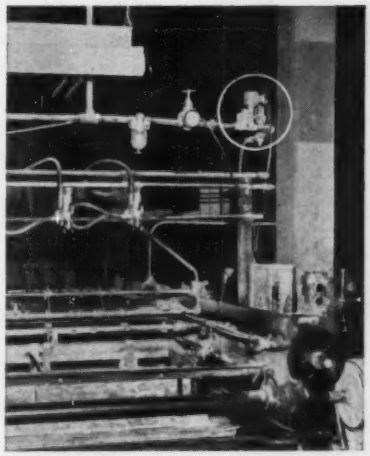
Similarly, the main valve seats seal on "O" rings. Metal shoulders take the shock in such a way that the "O" ring seal is merely kissed by the seat in the sealed position; since they are only minutely flexed they don't fatigue or lose their resilience.

100 Million Cycle Guarantee

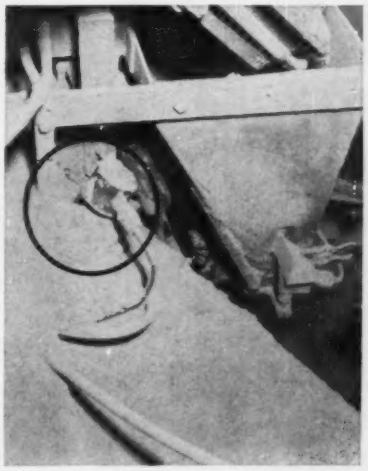
Because of the short solenoid plunger stroke and the elimination of friction, there seems to be no limit to the endurance of the solenoid coils in "Mach 2" Valves. We back up this statement by guaranteeing the coil life for a minimum of 100 million cycles. For six years "Mach 2" Valves have undergone test. Valves have been placed in some of the toughest applications we could find to test their performance capabilities in actual service before introducing them to the market. Some were installed in plants where they were subjected to very fast-cycling, continuous operation. Others have been operating where they are exposed to excessive dirt, dust and dampness, and in all cases the "Mach 2" Valves are performing flawlessly. In fact, some operators balked at having us remove them for inspection. To test the new waterproofing treatment of the "Mach 2" coils, one of the units was completely submerged in a container of water on April 26, 1959, and it is still functioning perfectly.



Crescent "Mach 2" 4-Way Valve on a roofing paper machine. This machine operates 24 hours per day, 7 days per week.



Large printing press used to imprint cardboard cartons. "Mach 2" 3-Way Valve controls spray nozzles which apply "offset spray." Production speed of this machine is 2000 cycles per hour.



This Crescent "Mach 2" 4-Way Valve operates the hopper doors at a cement batching plant. The valve has been operating at 1400 cycles per day surrounded by dry cement. We actually had to dig the cement away from the valve to get a picture.

Write for the "Mach 2" Catalog

Crescent® "Mach 2" Solenoid Pilot Operated Air Valves represent a significant breakthrough in "the cycling speed barrier" and in valve life and operating dependability. We hope you will approve of the unusual name, "Mach 2." We know you will approve of the low-cost, downtime-free performance the "Mach 2" will deliver on your tough jobs. Please write to Barksdale Valves, 5125 Alcoa Avenue, Los Angeles 58, California, and request an advance copy of the "Mach 2" catalog.

Circle 440 on Page 19

Schlieren photograph showing heated air rising from Malleable chain link at 1200° F.

For Hot Parts... Use Malleable

Heat them up, cool them off—ten thousand times. Heat them up, keep them hot—indefinitely . . . you'll find you can count on Malleable iron castings for an exceptional combination of safety and economy.

New research demonstrates that the rugged room-temperature characteristics of Malleable castings remain virtually unchanged up to 800° F! More important—from 800° F. to 1,200° F., Malleable castings are unique in providing safe, dependable service **without** sudden drop in strength.

Let a nearby Malleable castings producer help you develop better, more economical parts for elevated temperature applications. Send drawings or an outline of your requirements to any of the progressive companies that display this symbol—

MEMBER

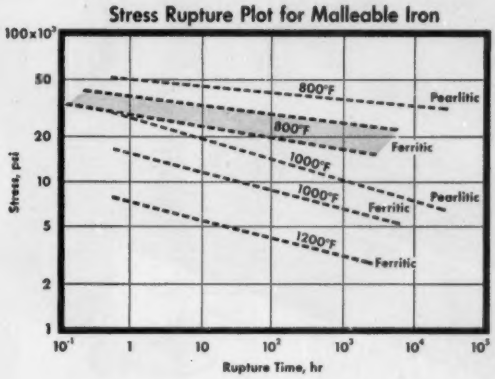
MALLEABLE CASTINGS COUNCIL

For detailed information on "Use of Malleable Castings in Elevated Temperature Applications," contact any company listed on the opposite page, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

Get Dependable Strength At Elevated Temperatures With Tough, Economical Malleable Castings

Malleable iron castings give you excellent service under rugged conditions at temperatures up to 800F. Even at temperatures as high as 1200F, at reduced stress levels, Malleable castings offer uniformly predictable properties.

Compare these stress-rupture curves for Malleable iron with other ferrous metals. Malleable's are straight, gradually declining curves . . . not curves that break sharply and suddenly downward. With Malleable you can count on long life.



At temperatures from sub-zero to over 800F, Malleable delivers more strength per dollar than any other metal, ferrous or non-ferrous. In addition, your products will profit from Malleable's exceptional machining ease and uniformity, and the efficiency of the casting process.

Eight years of service at 900F without a failure! That's the history of these pearlitic Malleable conveyor chains carrying aluminum billets through a furnace. Similar Malleable chains have been subjected to temperatures as high as 1300F in sheet steel normalizing furnaces for years without failure.

Subjected to dynamic stresses at temperatures from 500 to 750F, these pearlitic Malleable truck and bus diesel engine pistons commonly provide more than 40,000 hours of service . . . over 1,000,000 miles!

Free Engineering Aid — To help you more exactly evaluate the possibilities of producing better products at lower cost with Malleable castings, send for *Data Unit 108—Elevated Temperature Characteristics of Malleable Iron Castings.* Your copy is available from any foundry listed below, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

For Quality and Economy... Use MALLEABLE

For Service In Your Area Contact...

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

IOWA
Iowa Malleable Iron Co., Fairfield

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

MISSISSIPPI
Mississippi Malleable Iron Co., Meridian

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

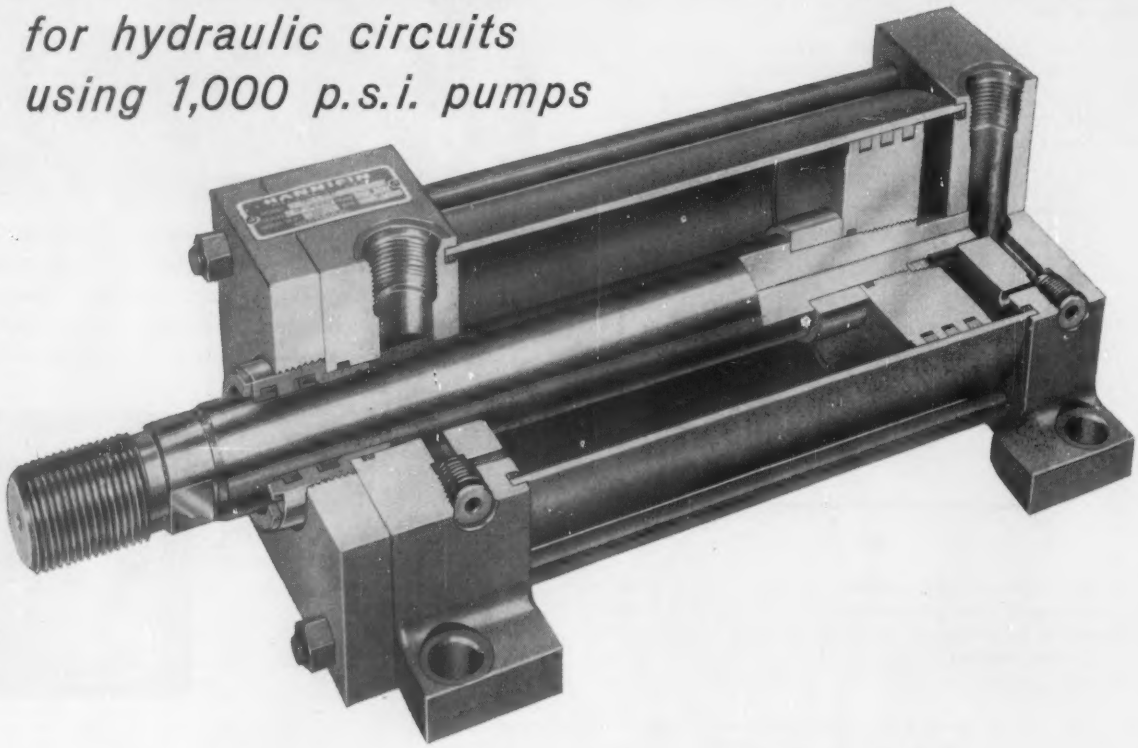
TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

NEW FROM HANNIFIN
THE THOUSAND POUND LINE!

for hydraulic circuits
using 1,000 p.s.i. pumps



- *A true hydraulic cylinder – not a modified air cylinder*
- *Offered in nine bore sizes – 1" through 8"*
- *Every model withstands at least 1,000 p.s.i. in every bore size*
- *Built to save you money – yet not "built to a price"*

Now, for the first time in hydraulic cylinder manufacture, Hannifin offers a top quality cylinder tailored to the medium-high-pressure hydraulic circuits you operate off 1,000 p.s.i. pumps.

Series "L," the "Thousand Pound Line," is NOT a modified heavy duty air cylinder. It is built for the job . . . with steel heads and steel barrel for full compliance with J.I.C. hydraulic recommendations. Other extra-quality features include an induction hardened and hard chrome plated rod, nodular iron piston with cast-iron piston rings — leakproof "Lipseals®," optional — longer cushions on cushioned models, and the Hannifin-developed bronze cartridge gland with both "Lipseal®" and "Wiperseal" to keep the rod drip-free. S.A.E. straight thread "O" ring ports as recommended by J.I.C. are optional at no extra cost just as they are in the Hannifin heavy duty Series "H" hydraulic cylinder.

Parker-Hannifin field engineering service can help you meet your needs precisely, help you select the proper Hannifin cylinder for any service, air or hydraulic. Call your nearest Parker-Hannifin sales office or write direct for our new bulletin giving all dimensions of Hannifin Series "L" cylinders.

HANNIFIN COMPANY
A DIVISION
515 South Wolf Road • Des Plaines, Illinois
PNEUMATIC AND HYDRAULIC SYSTEM COMPONENTS

3077-PH

Circle 442 on Page 19

WANTED

the toughest wear problem known for

CARMET CARBIDE

• the hardest metal known •

★★★★★ If you've got a real wear problem, it's time you take a long, hard look at Carmet Cemented Carbides . . . and how they can extend operational life and reduce costs.

Carmet Cemented Carbides possess the perfect combination of extreme hardness, strength, and abrasion resistance for the battering that wear parts must take . . . the rubbing, scrubbing, sliding, and scraping.

Carmet Cemented Carbides have a compressive strength higher than any metal or alloy . . . cast, rolled, or forged. They are the hardest man-made metal . . . next to a diamond in hardness, yet far tougher . . . three times stiffer than steel, and up to 100 times more abrasion resistant.

And you can put this hardness and wear resistance where it will do the most good. Carmet wear parts can be made in practically any shape . . . adapted to any function.

For all the facts on carbide wear parts, get Carmet's new booklet on design for wear resistance. It's packed with charts, graphs, case histories, and special design criteria for top wear parts performance. Ask your local A-L representative for a copy, or write: ***Allegheny Ludlum Steel Corporation, Carmet Division, Oliver Building, Pittsburgh 22, Pennsylvania. Address Dept.*** *MD-12.*

1005

CARMET®

CEMENTED CARBIDE • DIVISION OF ALLEGHENY LUDLUM

problems
CHIEF DESIGNER

"Miniaturization makes power transmission extra-tough . . . but G.S. Precision Gearing specialists can give us a big head-start on our new designs."

"For years we've brought in G.S. Precision Gearing experts at beginning stages of design jobs —and it has paid off, whether in modifying existing products or breaking trail in radically new directions. Miniaturization has given us even tougher Precision Gearing problems — but G.S. is still saving us all kinds of grief by leading us to practical power transmission methods early in the game.

"G.S. makes the full range of Small and Intermediate Gearing: Spurs, Spiral, Bevels, Helicals, Internals, Zerols, Clusters, Ratchets, Splines, Hobbing, Worm Gearing. That means they're free to prescribe the *right* kind of Gearing — and then turn around and *produce* it right, run after run (as our production people will tell you).

"I guess it all boils down to this: We want top quality, so we deal with top sources — and G.S. is known all over the country (among both big and little companies) as *the* source of precision-made Small and Intermediate Gearing in production quantities — which, of course, means production economies. And there's one other thing that means a lot to all of us — their men are mighty nice guys to work with! I'd recommend that you put them on *your* design team when you come up against a Precision Gearing problem."

YOU'LL FIND G.S. GEARING IN TOP QUALITY PRODUCTS LIKE THESE . . .

Adding Machines • Aircraft Carburetors & Fuel Metering Systems • Aircraft Instruments and Radios • Automatic Musical Instruments • Automation Systems • Business Machines • Check Signing & Protecting Machines • Clippers for Barbers, Animal Shearing & Hedge Trimming • Cloth Cutting Machines • Coin Changers & Counters • Communication Equipment • Control Mechanisms • Electric Fans • Electric Motors • Floor Polishers, Sanders, Scrubbers, Sweepers • Food & Drink Mixers, Blenders • Home Appliances • Lawn Sprinklers • Machine Tools • Meat Tenderizers, Grinders, Slicers • Military Equipment • Motion Picture Cameras & Projectors • Optical Instruments • Outboard Motors • Pneumatic Production Tools • Radio & Radar Tuning Assemblies • Radio Anti-backlash Gears • Range Finders • Record Changers • Sewing Machines • Steel Strap Stretchers • Step Switches • Tapping, Drilling & Threading Equipment • Telephone Dials • Television Sets • Thermostatic Controls • Typewriters • Vending Machines • Washing Machines.

SEND FOR G.S. *illustrated folder! See where and how we mass-manufacture Small Gearing to uniformly fine tolerances. Folder contains 23 pictures of Small Gears, plant view, as well as Diametral and Circular Pitch Tables. Ask for your copy on company stationery, please!*

FRACTIONAL HORSEPOWER GEARING

GEAR Specialties, Inc.

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SPURS • SPIRALS • HELICALS • BEVELS • INTERNALS
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WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARING

AGMA *44 Years of Specializing in Small Gearing!*

Gasket engineering

LATHE-CUT RINGS vs. MOLDED O-RINGS

Lathe-cut cork-and-rubber rings are compressible. They often permit wider tolerances in the flanges . . . opening the way for worthwhile savings in machining time. And their initial cost is lower.

If you now use molded rubber O-rings, chances are you can reduce costs considerably by changing to lathe-cut rings of Armstrong cork-and-rubber materials. At the same time, it may be possible to effect savings in machining time and inventory costs. Here's why.

A molded O-ring can cause sealing problems if the ring is not exactly the right size in cross section. If the ring is too small, it will not seal. If it is too large, it will prevent flange contact.

The reason, of course, is that rubber is non-compressible. Under pressure it flows laterally, but does not decrease in volume. As a result, rubber O-rings must be made to very close tolerances to allow a perfect fit between flanges.

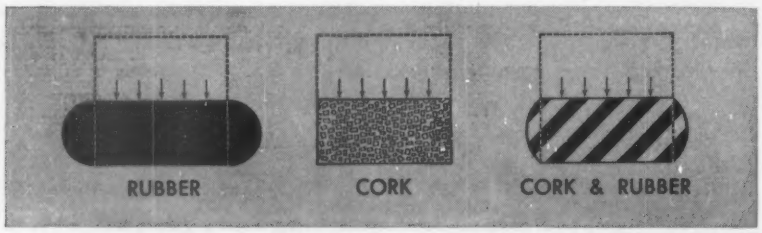


Figure 1. Rubber is non-compressible. Under pressure it flows laterally—does not decrease in volume. Cork is truly compressible. It exhibits no lateral flow under pressure. Cork-and-rubber gives controlled compressibility. Lateral flow can be controlled by varying the composition of the material.

Lathe-cut O-rings of cork-and-rubber compositions offer a number of advantages over molded O-rings. In such compositions, the compressibility can be controlled. The material can be made nearly as incompressible as rubber. The per cent of compression for cork-and-rubber rings may range from 20% to 33%.

This means that wider tolerances are permissible with cork-and-rubber rings, since the lateral flow can be controlled. The result may be a savings in machining time. In some cases, a reduction of inventories may be possible because one size of cork-and-rubber ring may work where two or more molded O-ring sizes might be required. These economies, of course, are in addition to the lower first cost of lathe-cut rings.

Cork-and-rubber O-rings give the imperviousness of rubber, since the rubber binder encloses each cork particle in a continuous matrix. The temperature limits of cork-and-rubber materials vary with the composition of the material and the contained fluids to which they are exposed. In general, continuous operating temperatures should not exceed 300° F.

The solvent resistance of cork-and-rubber compositions is comparable to straight synthetic rubbers of corresponding base polymers. For example, cork-and-chloroprene-type synthetic rubber is normally used with lubricating oils and for general purpose applications where some swell is desired or can be tolerated.

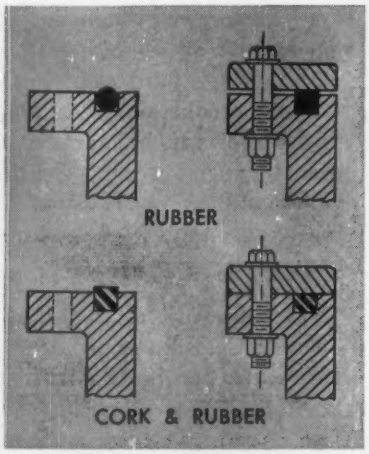
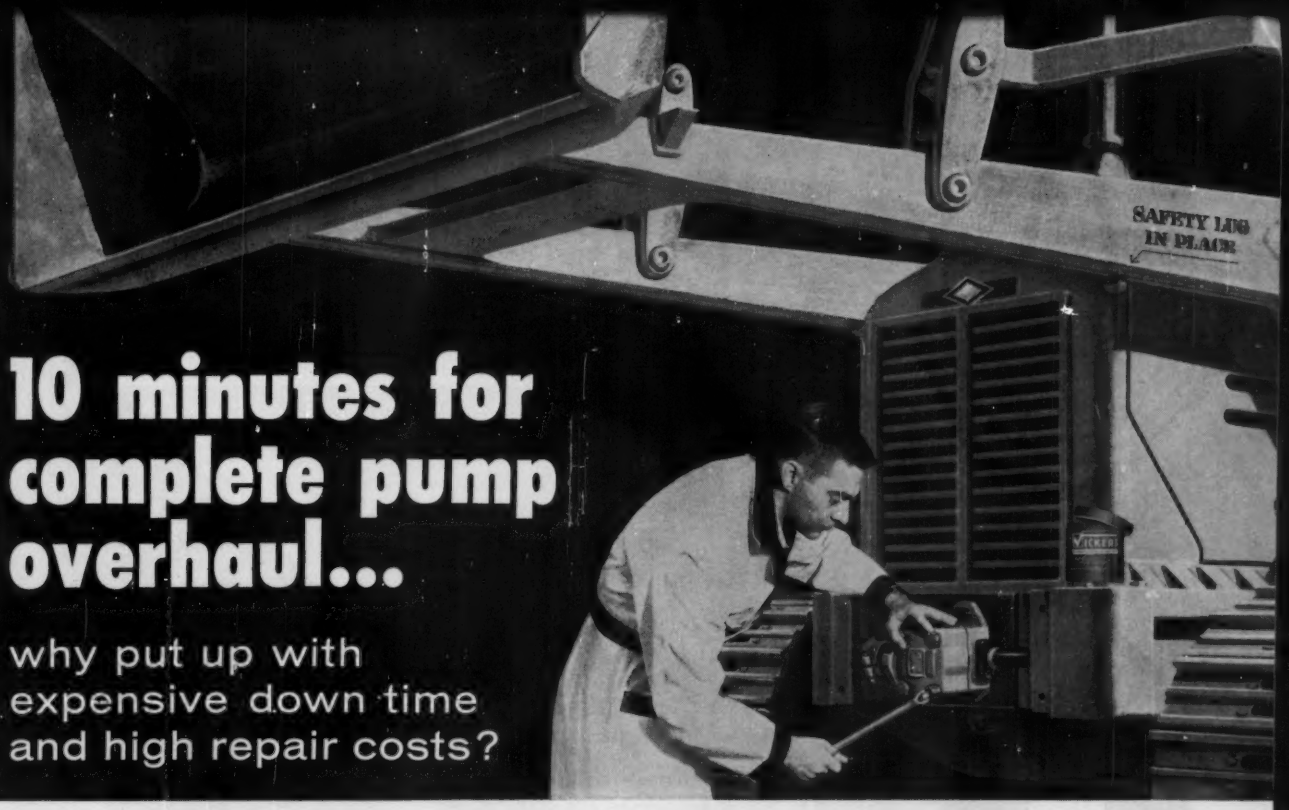


Figure 2. If O-rings made of incompressible rubber are slightly oversized, the joint will not close. Compressible cork-and-rubber rings may be cut to full channel width and from 20% to 33% deeper than the channel.

Cork-and-nitrile-type synthetic rubber provides good gasoline and aromatic-solvent resistance and has less tendency to swell or stick on metal surfaces.

If you have a problem with O-rings, perhaps we can help you. Send complete details of your application to us. And, for a free copy of our Gasket Design Manual, containing detailed information on gasket design and selection, write Armstrong Cork Company, Industrial Division, 7112 Dean Street, Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS



10 minutes for complete pump overhaul...

why put up with expensive down time and high repair costs?

on the spot
maintenance with

VICKERS®

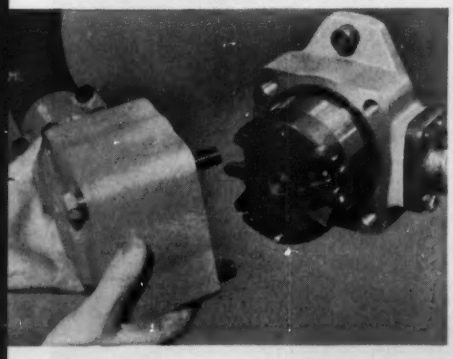
"High Performance" Pumps*
keeps your jobs on schedule

*PATS. & PATS. PENDING

Without removing the pump from the vehicle, and without disconnecting hydraulic lines, the new Vickers "High Performance" pump can be completely overhauled by simply inserting a new pumping cartridge. The pumping cartridge contains all wearing parts in one replaceable unit and results in new pump performance. Write for Bulletin No. M5108 for performance characteristics.

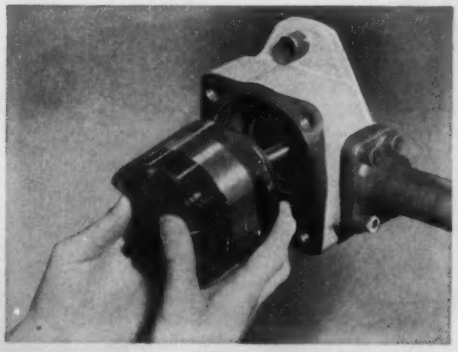
2 min

1. After safety, cleanliness and draining instructions have been followed per vehicle manufacturer's recommendations, take out four cover bolts and remove cover.



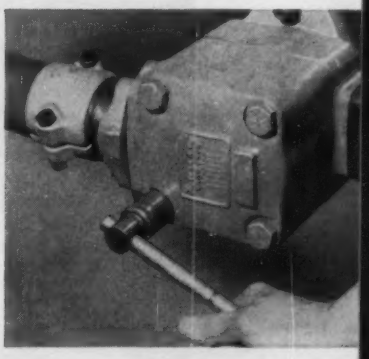
5 min

2. Take out old pump cartridge and insert new one. The cartridge includes cam ring, rotor, vanes, etc. —all parts in one assembly.



10 min

3. Replace cover and you have the equivalent of a new pump ready for long, trouble-free service.



8212

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Mobile Hydraulics Division
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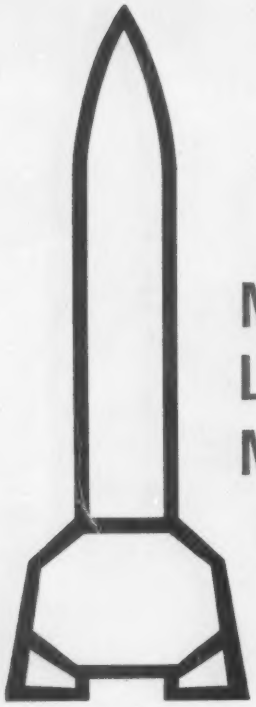
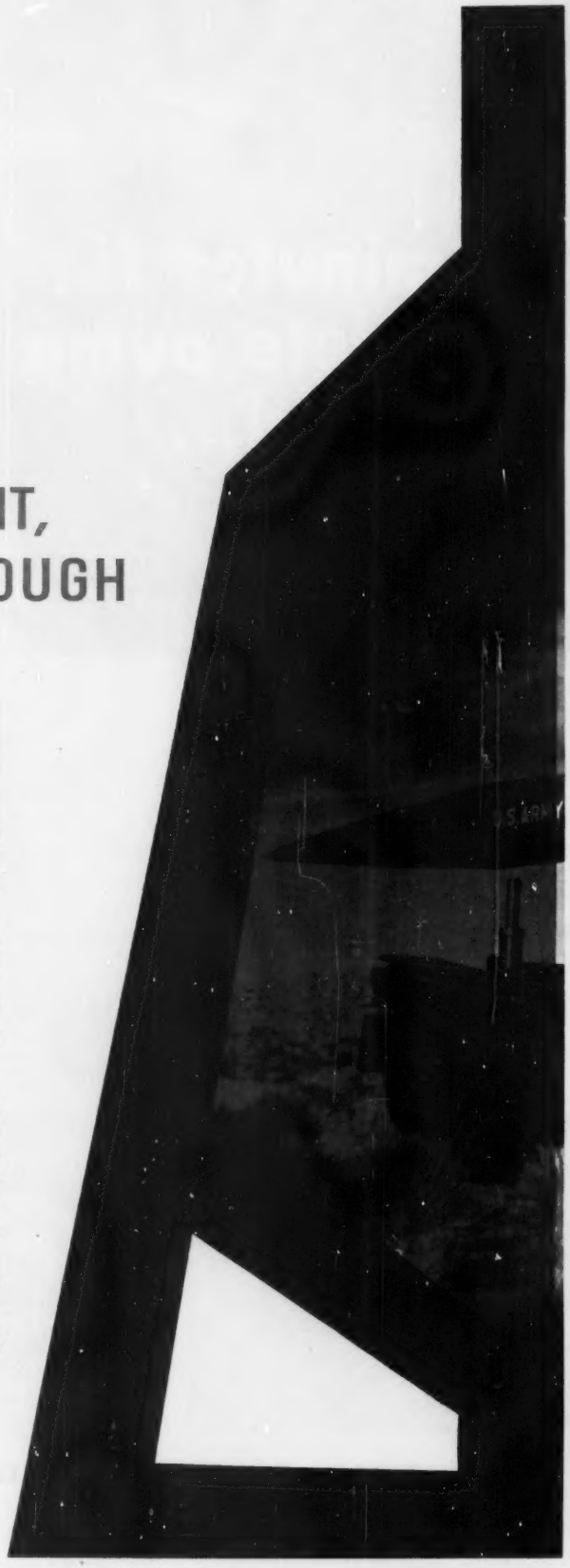
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Circle 445 on Page 19



MISSILE LAUNCHER MADE MOBILE-LIGHT, TAKEOFF-TOUGH WITH N-A-XTRA HIGH-STRENGTH STEEL



A battlefield might be anywhere. Wherever it is, there may be a need for the new 10,000-pound, 36-foot Sperry-Rand U.S. Army Sergeant missile. That's why the launching station on which the missile is assembled, aimed and fired must be light enough to be transported by land, sea or air. Yet it also has to be rugged and strong enough to assure the launcher's availability for subsequent firing.

N-A-XTRA steels meet all the conditions of light weight, high strength and impact resistance. Pound for pound, they're nearly three times stronger than mild carbon steel. They are used, not only in this mobile missile launcher, but in many other defense products and in commercial equipment such as earth-moving vehicles, heavy machinery and pressure vessels.

Fabrication qualities are an N-A-XTRA bonus. Even at extreme subnormal temperatures, they remain tough and readily weldable. Conventional methods—cold forming, gas cutting, shearing and machining—give superior results, too. For further information, write Product Development Department, Great Lakes Steel Corporation, Detroit 29, Michigan.

N-A-XTRA

A PRODUCT OF

GREAT LAKES STEEL

Detroit 29, Michigan

Quenched and tempered N-A-XTRA, *the best low carbon extra-strength alloy steels you can buy, are available in four levels of minimum yield strength, from 80,000 to 110,000 psi. They are tough at normal and subnormal temperatures and can be readily and reliably welded. Sizes range from ⅛" to 1" thick, up to 72" wide and up to 35' long.*

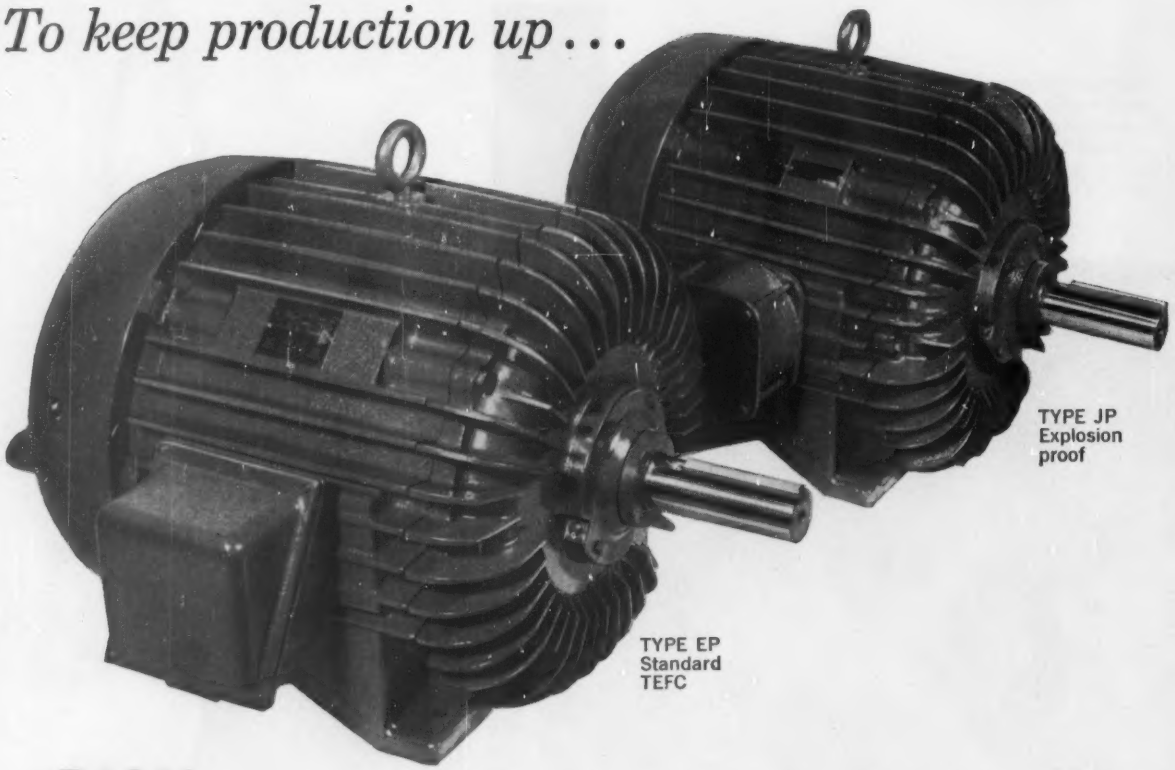
Steel

Look for the STEELMARK on the products you buy; place it on the products you sell.

***Great Lakes Steel is a Division of* NATIONAL STEEL CORPORATION**

Circle 446 on Page 19

To keep production up...



PICK FROM THIS PROTECTED PAIR...

Here's a power-packed pair of Wagner® totally-enclosed fan-cooled motors —Type EP, standard, protected against damage from dust, abrasive, fumes, steel chips or filings; and Type JP, explosion-proof, for safe use in specified hazardous locations.

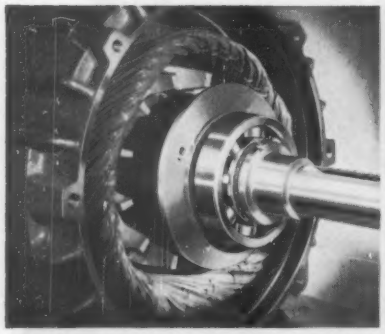
They'll keep your production rates up, delivering full rated horsepower under the toughest conditions . . . staying on the job with dependable, continuous service that means peak output. They're the perfect pick, for individual machines or for automated lines.

In the design illustrated, these motors are built in ratings through 100 hp in NEMA frame sizes 182-445U. Let your Wagner Sales Engineer show you how this protected pair (or larger Wagner enclosed motors through 500 hp) gets the job done. Call him, or write us for Bulletin MU-224.

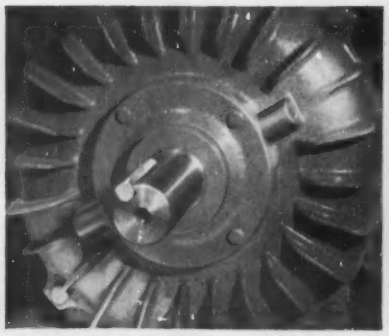
Wagner Electric Corporation

6404 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI

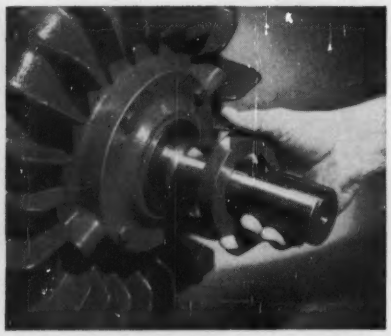
WM60-19



HEAVY-DUTY BALL BEARINGS... The ball bearings used in these motors are of the highest quality, with more than ample capacity to provide long, troublefree service under heavy loads.



BEARINGS CAN BE RELUBRICATED... Factory lubrication will last for many years under normal service, but openings are provided to permit relubrication that adds years to motor life under severe conditions.



SECURELY SEALED FOR LOW MAINTENANCE... Both ends of these motors have running shaft seals to keep the bearings clean. Bearing housings are effectively sealed to prevent escape of grease.

Smallest of the Small. A pigmy beetle could easily crawl through the eye of an ordinary sewing needle, as shown by this equally magnified view of both. Among the tiniest of insects, some species of pigmy beetles reach about one-hundredth of an inch in length.

Miniature for Missiles. This tape recorder, shown one-sixth actual size, is a vital unit in the communications system of the Army's "talking satellite." Constant low-torque and quiet operation of MPB bearings in it maintain accurate tape position.

Man with Miracles. Like all MPB Sales Engineers, Pete Weinert helps solve miniaturization problems — by acquainting people with MPB service and facilities for engineering, research and experimental work. He's ready to do the same for you.

Miracles in Miniaturization

ACTUAL SIZE OF THE MPB BEARINGS IN TAPE RECORDER SHOWN ABOVE

Little Things That Count. There's nothing new, in the larger sense, about ball bearings. But miniaturization of these familiar components is a wholly modern development. Forty years ago, for example, MPB was first to manufacture bearings with O.D.'s as small as ⅜", and with precision that brought new aid to science and industry. Today, after continual pioneering in miniaturization, MPB produces over 500 types and sizes of bearings, ranging down to 1/10" O.D., with specials as required. Our catalog brings you details on these bearings. Write for it, or for engineering advice, to **Miniature Precision Bearings, Inc.**, 812 Precision Park, Keene, N.H.

MPB *Helps you perform miracles in miniaturization*

Circle 448 on Page 19

Plastic fastened to metal— firm and weather-tight with RIVNUTS®

Large transparent plastic panels form the cockpit windows of the Vertol Aircraft Company's new YHC-1A helicopter. The plastic is firmly secured to the airframe by B. F. Goodrich RIVNUTS. About 300 are installed—quickly and easily—resulting in a finished seal that withstands both vibration and weather extremes.

One man fits the RIVNUTS into the hat section, working from one side. These RIVNUTS act as blind nutplates. Attachment screws tighten the molding strips, rubber and plastic in a firm, weatherproof grip.

This use of blind-fastening RIVNUTS insures a simple and very satisfactory method of window installation. In case after case, RIVNUTS speed assembly, cut labor costs, simplify design. If you'd like recommendations on a specific fastening problem, please send a print of your part.

YOU CAN IMPROVE FASTENING IN SHEET METAL, TUBING, TANKS WITH RIVNUTS

New RIVNUT Data Book visualizes how RIVNUTS work, shows construction and ease of installation in many forms or types of materials. For free copy write Dept. MD-12, *B.F.Goodrich Aviation Products, a division of The B.F. Goodrich Company, Akron, O.*

B.F.Goodrich *aviation products*

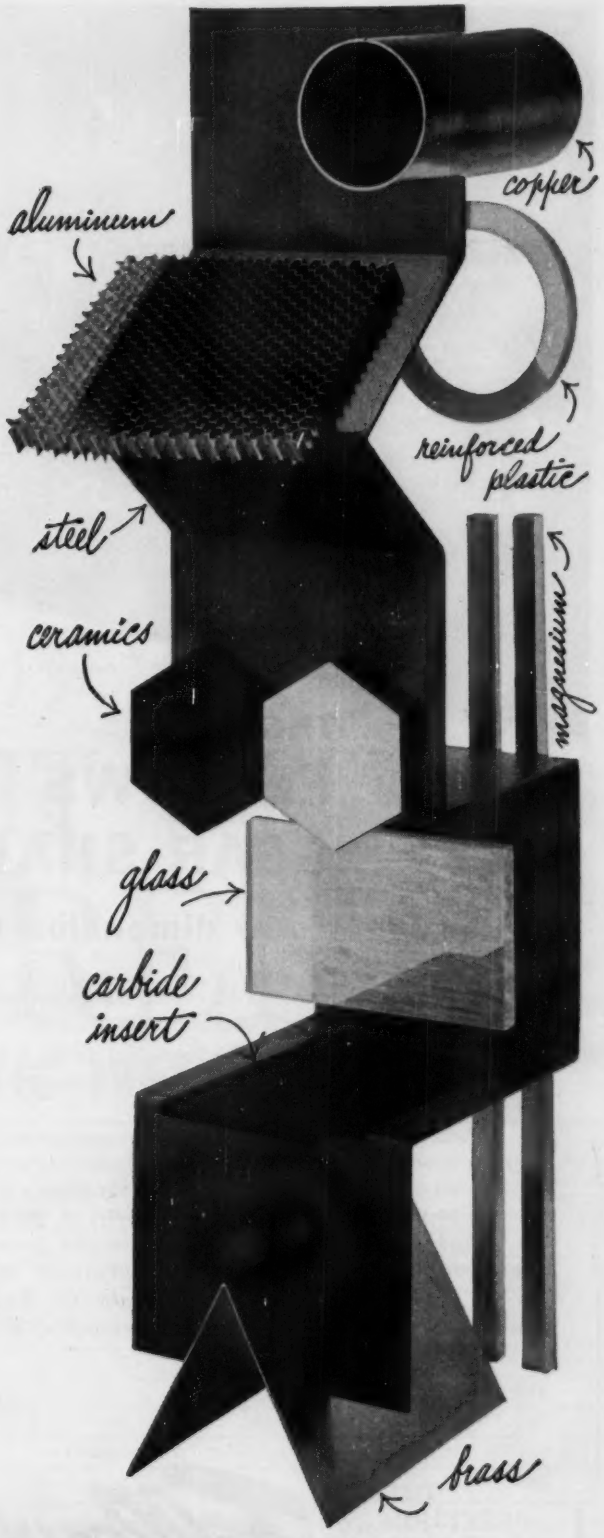
WHAT DO YOU WANT TO BOND TO WHAT?

Take a structural material—for instance, any of the materials shown to the right. Want to join it to itself or another material? Then chances are that SCOTCH-WELD® Brand Structural Adhesives are your best fabricating answer. This modern high strength method of joining materials permits improved design and production techniques . . . cuts costs . . . offers unique benefits.

For example: Smoother contours result when mechanical fasteners are eliminated. Fabricating complex shapes—often impossible or too expensive with ordinary fastenings—is made easy and economical with SCOTCH-WELD Adhesives. In fact, costly complex castings can often be replaced by two or more inexpensive simple castings bonded together with SCOTCH-WELD Adhesives. And lighter gage materials may be used where desired, since stress is spread over a wide area. Often, too, inspection and production steps can be eliminated. Another benefit—unusual combinations of materials which can be joined in no other way can be bonded perfectly with SCOTCH-WELD Adhesives.

Throughout the metalworking industry, bonding with SCOTCH-WELD Brand Structural Adhesives is improving quality, speeding production and cutting costs.

SCOTCH-WELD Adhesives may be the answer to your design and production problems . . . and improve your product at the same time. For full information write on your company letterhead, outlining area of interest, to: AC&S Division, 3M Company, Dept. SBR-120, St. Paul 6, Minn. "SCOTCH-WELD" is a Reg. T.M. of 3M Co.



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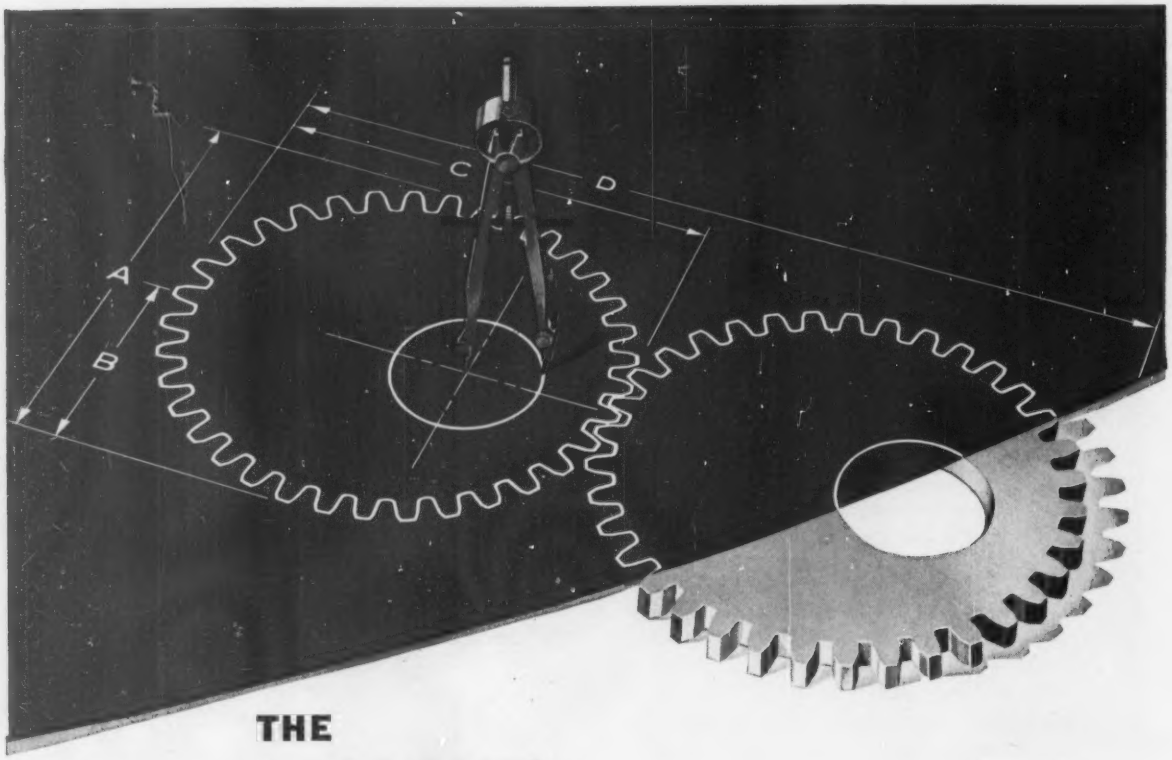
MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY



THE FELLOWS GEAR SHAPER

. . . adds a new dimension to your design techniques

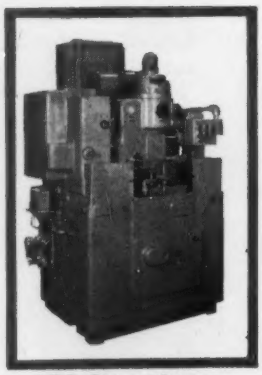
Designs that are right from a functional standpoint, often appear to be impractical from the standpoint of economical production.

To avoid compromising the functional design of non-circular gears or non-involute parts, many companies rely on the unique production capabilities of the Fellows Gear Shaper.

Parts that look complicated (and are complicated to design) become routine jobs in production on the Gear Shaper. Depending on design, some parts are best produced on single purpose machines. Many others can be produced on standard machines using special fixtures and standard, or special, Fellows cutters.

And, of course, the standard machines will generate internal and external spur and helical gears in a range from "miniatures" up to 120" P. D.

"The Art of Generating with a Reciprocating Tool", a fact-packed 48-page catalog, gives details on the versatile Fellows method. May we send you a free copy?



4GS Gear Shaper

THE FELLOWS GEAR SHAPER COMPANY
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THE PRECISION LINE

Fellows

Gear Production Equipment

Circle 451 on Page 19

IF IT MUST SLIDE ROLL STRIKE SEAL ...OR DEFY HEAVY LOADS AND ABRASION FROM −80° F. TO +250° F. ... MAKE IT WITH

ADIPRENE®

URETHANE RUBBER

PROPERTIES OF CURED ADIPRENE POLYMERS					
*Hardness, Shore A	75	88	95	97	99+
Hardness, Shore D	–	43	50	60	78
Modulus, 300%, psi	1100	2100	3200	7000	–
**Tensile Strength at Break, psi	4500	7000	8825	8500	8500
Elongation at Break, %	400	450	480	340	250
Izod Impact Notched ft.-lbs./in.	Flexed	Flexed	Flexed	20	1.2
Split Tear, ASTM-D 470 lbs./linear inch	25	50	155	160	200
***Compression/Deflection, psi @ 5% defl.	250	575	750	1800	6000
Rebound Resilience, %	45	45	40	42	45
Oil Resistance	Good	Excellent	Excellent	Excellent	Excellent
Low Temperature Brittle Point, F.	–80	–80	–80	–80	–80

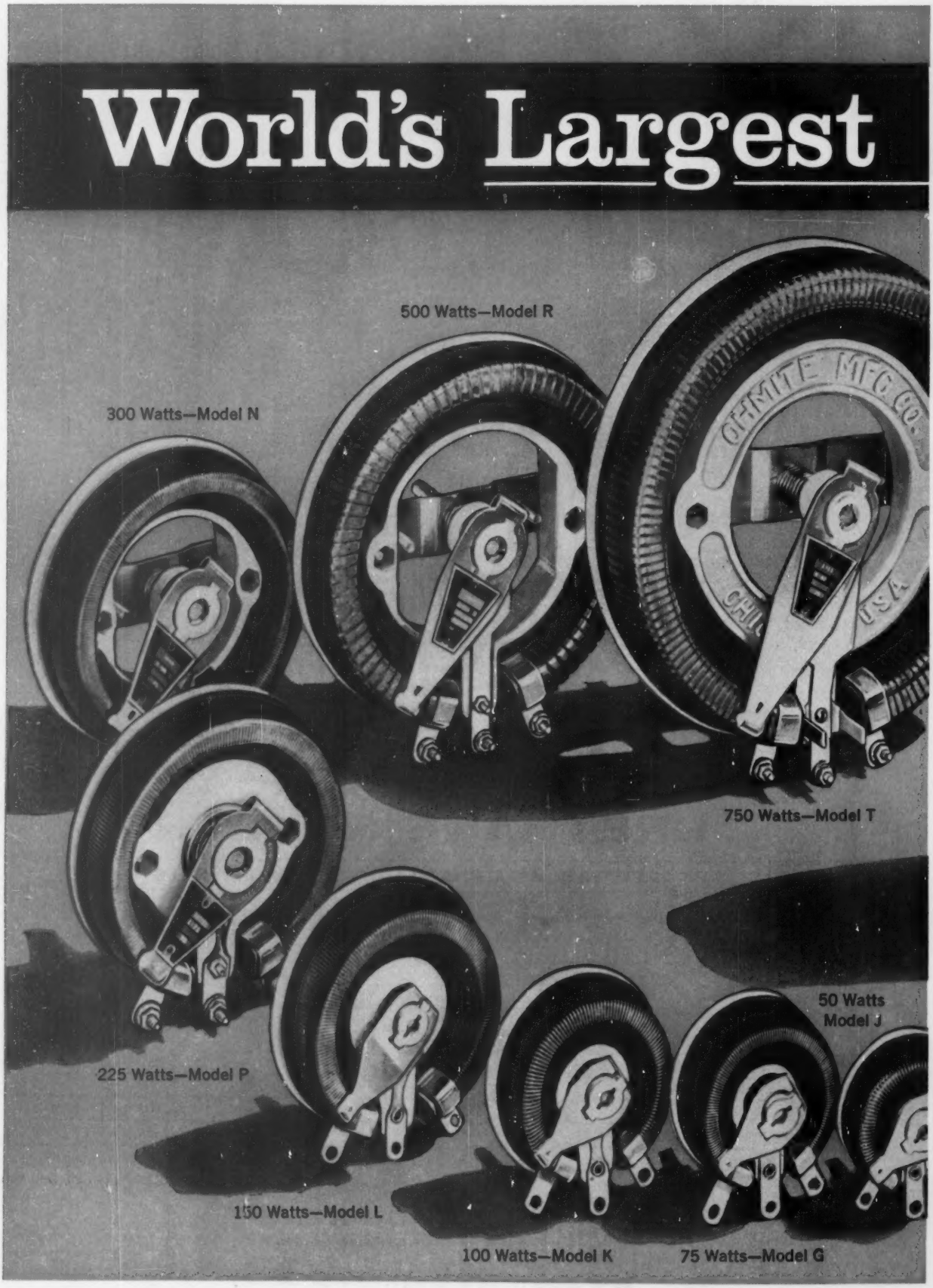
* Softer compounds ranging from 10 Shore A are also available. ** Samples pulled @ 1 in./minute (elastomer stocks normally pulled @ 20 in./min.) *** Shape Factor—1.0

For more information write E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MD-12, Wilmington 98, Delaware.

DU PONT REG. U. S. PAT. OFF. **ADIPRENE®** URETHANE RUBBER

Better Things for Better Living . . . *through Chemistry*

Circle 452 on Page 19


World's Largest
500 Watts—Model R
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GEMITE MFG CO.
750 Watts—Model T
50 Watts
Model J
225 Watts—Model P
150 Watts—Model L
100 Watts—Model K
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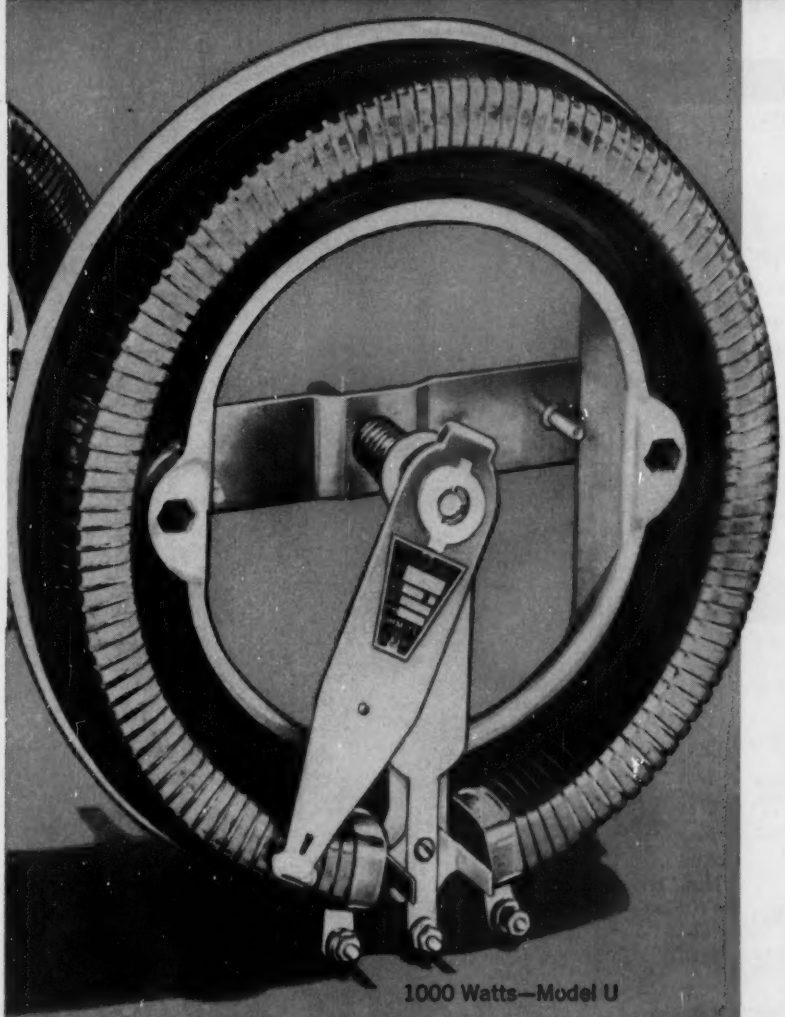
Selection

--SIZES
--VALUES
--STOCK UNITS
--SPECIAL FEATURES



1000 Watts—Model U

OHMITE offers the largest and most varied assortment of power rheostats ever developed.

You can choose from 413 *stock* commercial sizes and types ranging from 12½ to 1000 watts . . . or from over 400 *stock* MIL-R-22A sizes and values, with "special fast delivery" on *all* other MIL units. You can find, for example, scores of different shaft styles, sizes, configurations—already engineered and waiting. Literally, hundreds of other special features take care of any rheostat application envisioned today.

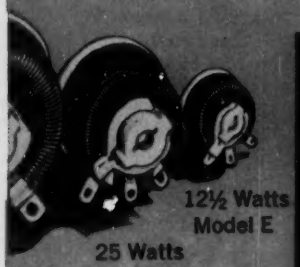
But Ohmite rheostats give you more than just "largest selection." Ohmite wire-wound units of *all ceramic and metal construction* represent the highest degree of operational reliability ever attained in rheostats. They bring you the backup of industry's greatest reservoir of engineering talent in rheostat design and application.

Because of this, you find more Ohmite units in use than all other makes combined. On your next project calling for rheostats, make your selection from the smooth, close control units preferred throughout industry.

OHMITE MANUFACTURING COMPANY
3618 Howard Street, Skokie, Illinois

Stocked by the Factory and Electronic Distributors Everywhere

Write on company letterhead for Catalog & Engineering Manual 58



12½ Watts Model E

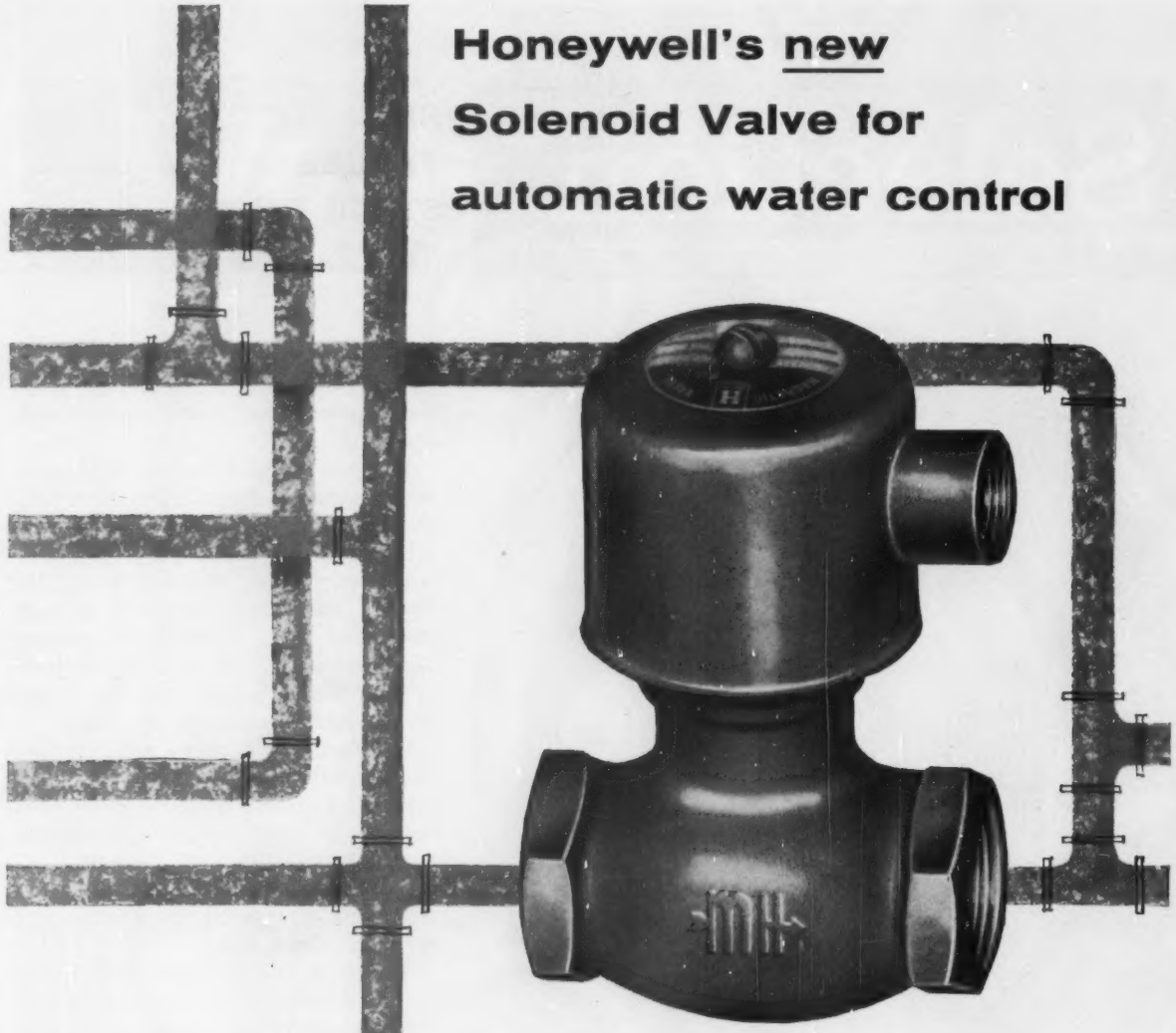
25 Watts Model H

OHMITE RHEOSTATS

Rheostats
Power Resistors
Precision Resistors
Variable Transformers
Tantalum Capacitors
Tap Switches
Relays
R.F. Chokes
Germanium Diodes
Micromodules

Circle 453 on Page 19

Honeywell's new Solenoid Valve for automatic water control



1. No water hammer
2. Noiseless
3. New high capacity
4. Pilot-operated
5. Easy-to-clean

New Honeywell high capacity Solenoid Valve is designed to eliminate water hammer. Use this pilot-operated, soft-seated valve for reliable, automatic on-off control of water or other light, non-viscous, non-corrosive fluids.

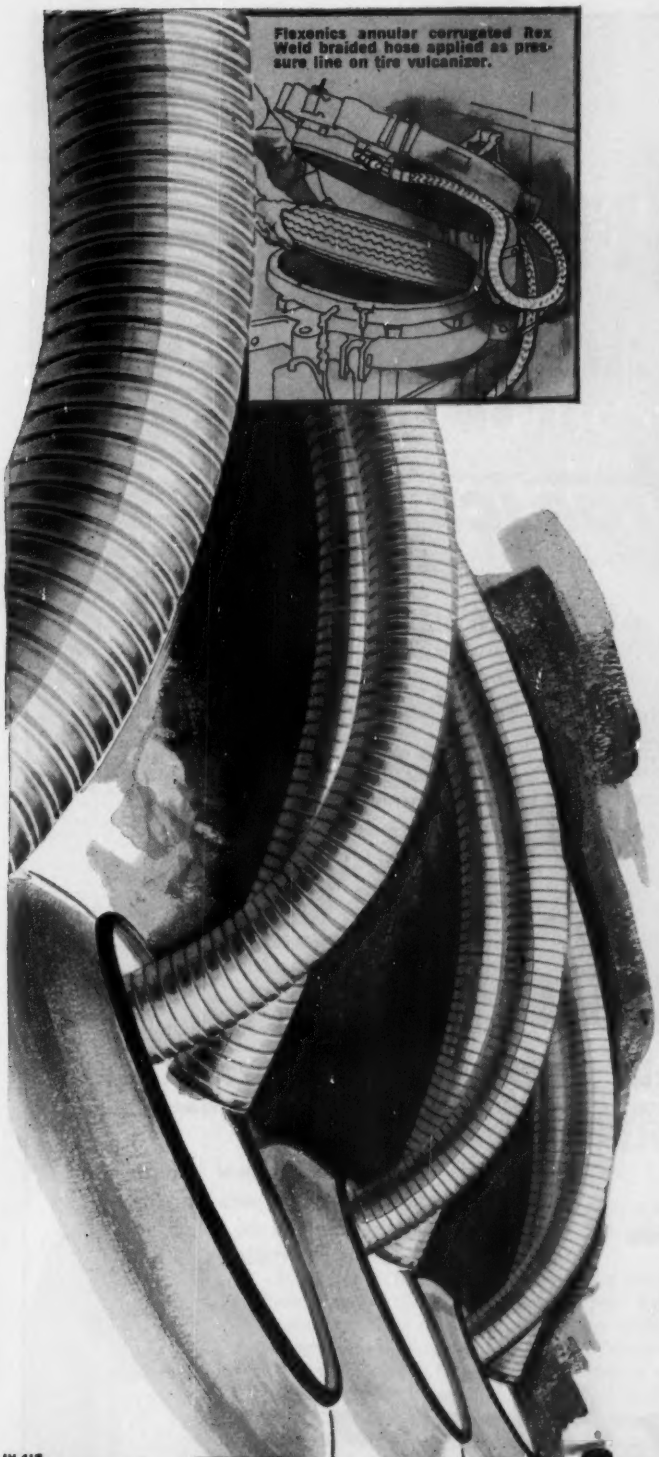
Available in ½" and ¾" sizes. Both valves have same high flow capacity as similar hand glove valves. Valves are available for normal and chilled water applications . . . operates from any standard SPST controller or on-off switch. Power head can be rotated 360° for easy wiring. Valve may be cleaned without removing from the line. Body material is brass. For complete details and specifications, call your nearest Honeywell dealer; or write: Minneapolis-Honeywell, Department MD12-42, Minneapolis 8, Minnesota. In Canada, Honeywell Controls Ltd., Toronto 17, Canada.

Honeywell

First in Control

SINCE 1885

75th YEAR PIONEERING THE FUTURE



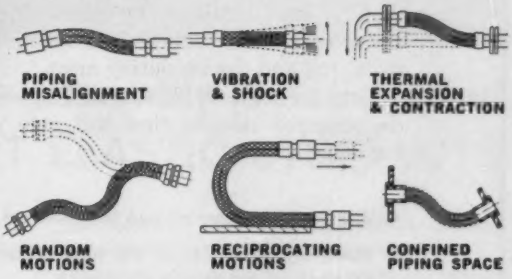
Meet any requirement for

METAL HOSE

with Flexonics engineering and big line of standards

Whatever your application requirements, Flexonics greater depth of product and experience means correct, quick, and *economical* solutions. Often, the most unusual design requirements are met with Flexonics extensive line of standard hose and fittings. You'll find Flexonics product and application engineers *more adept* at pin-pointing the performance standards the job demands. Depend on them.

Controlling effects of pressure and temperature in conveying solids, liquids or gases is the job of metal hose. Motion (illustrated below) is another factor common to all piping problems in one form or another. Flexonics sales engineers are "pipe motion specialists" . . . capable of anticipating and providing for any need in this direction.



(Left) A battery of Flexonics RT-6 galvanized steel hose assemblies installed in the tablet coating room of an internationally recognized pharmaceutical corporation. One hose is a hot air carrier (110°F), to hasten drying of tablet coatings. The other hose draws off excess air from the large pans, preventing powder dust.

Flexonics
corporation

In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ont.

EXPANSION JOINTS | METAL HOSE | SYNTHETIC HOSE | BELLOWS | AERO/SPACE COMPONENTS

SUBSIDIARY OF CALUMET & HECLA, INC.

ATTACH TO YOUR LETTERHEAD—MAIL TODAY!

FLEXONICS CORPORATION
1339 South Third Avenue, Maywood, Illinois

Please send me my personal copy of the Flexonics Metal Hose and Fittings Design Guide, covering in detail Flexonics products and services.

Circle 455 on Page 19

Taylor Fibre Co. announces acquisition of

Dytronics
INCORPORATED • ROCHESTER, MICH.

Leading producer of die stamped circuits

Taylor Fibre Co., a leading manufacturer of laminated plastics and vulcanized fibre, has acquired Dytronics, Incorporated, a leading producer of die stamped circuits for the automotive, appliance, electrical and electronics industries.

Die stamped circuits are *printed circuits* produced by a dry technique in which a heated metal-cutting die is used to delineate the conductor pattern and bond it to the base material by activating a thermoresponsive adhesive between the metal foil and the insulating areas.

Here are some of the salient features of die stamped circuits that will give you big benefits:

- **Unique base materials can be employed**
- **Electrical properties of the base materials are unimpaired during processing**
- **A greater variety of conductor metals can be used**
- **Uniformity of circuit configuration can be maintained indefinitely**
- **Exact duplication of circuit pattern is assured**
- **Exact line definition is provided**
- **Base material can be selected for electrical properties without consideration of chemical resistance**
- **Currents in excess of 40 amp can be handled**
- **Higher bond strengths can be produced**
- **High quality mass production is possible**

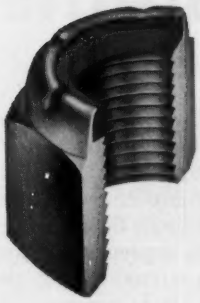
Send now for a copy of a new booklet we have prepared on Dytronics and die stamped circuits—you will be glad you did. Taylor Fibre Co., Norristown 47, Pa.

Taylor Fibre Co.
LAMINATED PLASTICS
VULCANIZED FIBRE

Circle 456 on Page 19

When frequent adjustment or dis-assembly is anticipated

USE NYLON INSERT ELASTIC STOP® NUTS



Extended re-useability is built into every standard Elastic Stop nut. The tough nylon locking collar does the trick.

It grips entering bolt threads with a plastic-smooth perfect fit that dampens impact loads, absolutely resists vibration, yet never galls or damages bolt threads. The nut may be "stopped" at any place on the bolt, whether seated or not, for precision adjustment. When the nut is wrenched off for routine maintenance, the nylon collar, due to its elastic recovery, tends to resume its original shape. Thus upon re-installation it grips the bolt threads as effectively as on the original installation. And this on-off cycle can be repeated over 50 times on any bolt of standard quality without loss of holding power.

The nylon locking collar can also be used to seal off liquid seepage along the bolt threads and to prevent moisture from entering the load carrying areas. It is inert to oils, gasolines, salt atmospheres and common acids.

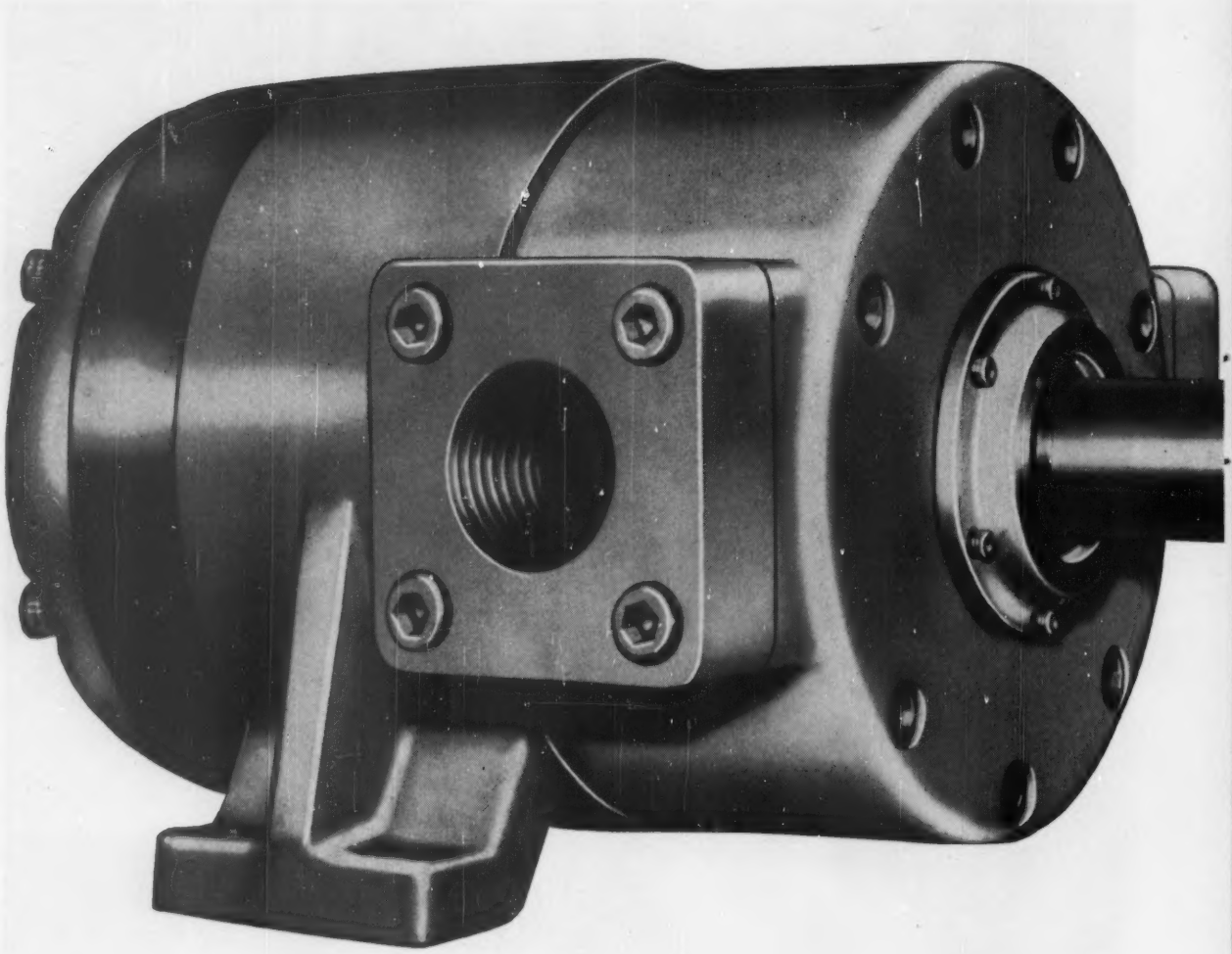
Consider the economy to you and your customers of this kind of fastener performance. Let us prove it to you. Ask for free test samples . . . or a copy of Recommended Test Procedures for Determining Locknut Re-Useability. Write: Elastic Stop Nut Corporation of America, Dept. S50-124 Vauxhall Road, Union, New Jersey.

ESNA®

for the ring reliability

ELASTIC STOP NUT CORPORATION OF AMERICA

Circle 457 on Page 19



Proper selection of constant Hydraulic Pumps for systems

By: Ellis H. Born
Director of Sales-Engineering
Denison Engineering Division
American Brake Shoe Co.
Columbus, Ohio

Whether to use a high pressure system or a low pressure system is perhaps the most basic decision the designer faces in developing the proper hydraulic system. This decision involves such factors as efficiency, space requirements and, most important, cost.

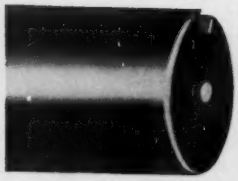
SPACE CONSIDERATIONS

Furnishing fluid horsepower is the function of a hydraulic system. Horsepower yield is determined by multiplying system pressure (psi) times flow rate (gpm) times a constant of 0.000583. Application of this formula reveals that a 5000 psi system develops five times the horsepower of a 1000 psi system at the same rate of flow. Accordingly, the 5000 psi system requires only 20% of the flow rate of a 1000 psi system to produce the same fluid horsepower.

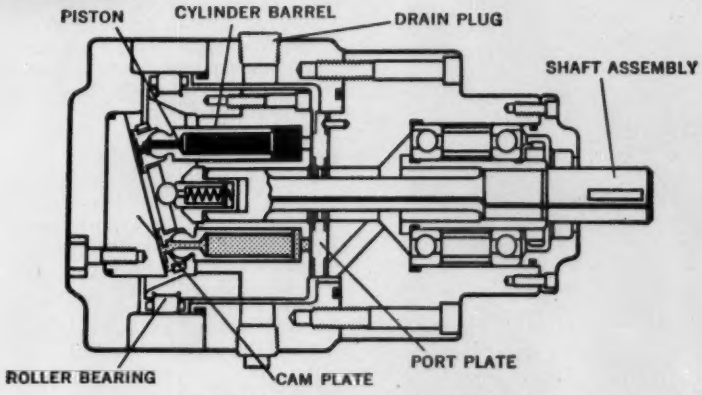
Reduced rate of flow permits designs which incorporate smaller valves, piping, hydraulic cylinders and reservoirs. Since reservoirs are often the largest single fluid component in a system, appreciable space savings can be realized with high pressure systems. If recommended hydraulic practice is followed, reservoir capacity is three times greater than the gpm displacement of the pump. Hence, for the same amount of fluid horsepower, reservoir capacity can be reduced as much as 80% in a high pressure system. The high

MOUNTINGS

FLANGE **FACE and PEDESTAL** **BRACKET**



Denison constant volume axial piston pumps offer volumes up to 122 gpm, pressures to 5000 psi, at their rated speeds of 1200 and 1800 rpm. Face, flange, bracket or pedestal mountings are available for ready adaptation to your particular installation. Models are available for either clockwise or counter-clockwise rotation.



DETAILS OF CONSTRUCTION

volume Axial Piston up to 5000 psi

pressure system not only allows savings in space through use of smaller components and capacities, but reduces the weight and mass of the hydraulic power package as well.

COST FACTORS

Use of smaller components in high pressure systems not only saves space, but affords worthwhile cost reductions.

Compact system elements cost less and because they are smaller, as well as lighter, assembly is easier and faster. Raw material requirements are also reduced. These advantages permit the over-all hydraulic system design to incorporate less weight and mass. The latter is especially important where portability is concerned.

SYSTEM EFFICIENCY

In any hydraulic system, a part of the generated fluid horsepower is used to force fluids through the system. Resultant line and pressure decreases are far less significant in high pressure systems. For example, a pressure drop of 50 psi represents a loss of 5% in a 1000 psi system, but only a 1% loss in a 5000 psi system. It follows that high pressure systems have an inherent efficiency advantage over low pressure systems.

The ability to provide sustained efficient power for a high pressure system is best fulfilled by a precision-built axial piston pump because of its low slippage rate and operating characteristics.

All internal forces created by hydraulic pressure against the moving parts are counteracted by the use of hydraulic balancing.

Using the principle of hydrostatic balancing eliminates the need for expensive and often cumbersome thrust bearings in the pump. This design minimizes pump size and allows a more compact pump or fluid motor package.

Other advantages are gained through hydrostatically balancing pistons and the cylinder barrel. For example, excessive loading of piston shoes against the cam plate is avoided. In addition, excessive loading of the cylinder barrel against the port plate is prevented, virtually eliminating wear caused by sliding action.

Life expectancy of internal axial piston pump parts is almost infinite since constant lubrication is supplied by system fluid.

Data and specifications on 5000 psi pumps, motors and controls are available from your Denison representative—located in principal cities—to assist you in developing hydraulic systems for maximum efficiency and economy.

NEW CATALOG FOR DESIGNERS AND ENGINEERS

Write for your copy of Bulletin 220—"Hydraulic Power to 5000 psi". Includes complete specifications, operating data and applications for Denison's full line of hydraulic pumps, motors and controls.

DENISON ENGINEERING DIVISION
American Brake Shoe Company
1240 Dublin Road • Columbus 16, Ohio

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RBW FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By Fred E. Graves

Fastening of "vibration" joints

With static assemblies, your only fastening worry is enough safe load capacity. But with dynamic loading, you also have to guard against loosening.

HIGH THREAD TENSION

You'll find one of the best locking mechanisms within the fastener itself: high thread tension. Obviously, the tighter the fastener, the higher the tension and the better the "lock."

CASE HISTORIES

(1) Textile looms notoriously suffer from vibration. Yet their bolts stay tight *without any locking device* when highly preloaded. (2) Heavy duty shakers had joint loosening problem which was solved for good when the maker switched to *high strength hex bolts torqued up almost to yield strength.*

Using split lock washers gives no such guarantee against loosening. It becomes equivalent to a solid washer at a relatively low load level. Once the screw has loosened to the point where the washer becomes a spring, it's too loose for safety.

When you can't fully utilize a high strength fastener, go to a bolt with prevailing torque lock nut; or to a unit that combines high thread tension along with a high off-torque value (such as RB&W's TENSILOCK fasteners—see Bulletin TL-2.)

With vibration joints involving thin gauge or sheet metal, it's better to use a *thread-cutting* screw, than a machine screw in tapped hole. It gives 100% depth of thread contact for more thread friction to resist backoff.

Some ideas for savings through cold forming

It generally costs less to cold-form a part than to machine it, since there's less scrap loss and more speed. The cold working strengthens the part, too—improves its physicals.

These four cases show what happened when designers and production men referred their needs in special parts to RB&W.

1. **Ball-head stud.** Formerly produced on screw machine, this truck mirror pivot suffered high scrap loss, cost 75% more than it did when RB&W produced it by cold forming and some secondary machining.

2. **Spacer.** Cost of this automobile trunk hinge spacer was cut 50% when RB&W cold-formers took on the job of pounding them out at high speed, finely finished and ready for installation.

3. **Taper plug.** Time and money were both saved by manufacturer of expansion bolts who came to RB&W to make these parts. Cold headers formed them faster than screw machines, and with zero scrap.

4. **Adjustment cam.** Cold forming affords the *only* economically feasible way to produce this part. Due to its large eccentric and hex end, machining and material costs would be excessive.

These examples typify a range of work from RB&W cold heading and cold forming facilities. RB&W also performs many secondary operations on parts to specification, such as drilling, slotting, knurling, etc. Best way to see whether you have a part that could cost you less is to refer it to RB&W for study. Write Russell, Burdsall & Ward Bolt and Nut Co., Port Chester, New York.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa., Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Circle 459 on Page 19

Completely integrated SOHIO Toledo Refinery

Swagelok®
TUBE FITTINGS

SOHIO Selected SWAGELOK Tube Fittings for just one reason — MAXIMUM RELIABILITY. This Toledo Unit refines 60,000 bbls. of crude oil per day in ONE CONTINUOUS OPERATION. Just consider the absolute necessity for leakproof tube fittings within this installation. No room for failure here! A highly successful example of total integration, Standard Oil Company of Ohio's Toledo Refinery is a functioning tribute to engineering skill and mechanical performance.

FOR MAXIMUM RELIABILITY SPECIFY Swagelok® Tube Fittings

Crawford Fitting Company • 884 East 140th Street • Cleveland 10, Ohio • Crawford Fittings (Canada) Ltd., Niagara Falls, Ontario, Canada

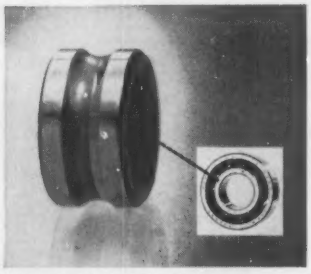
Circle 460 on Page 19

A NEW PRODUCT DEVELOPMENT FROM BARDEN

PERFORMING WELL IN A HOT SPOT

As every parent knows, small boys have an amazing capacity to perform well in heat that would fell the average adult. In much the same way, BarTemp* ball bearings operate effectively up to 575° F., permitting synchros, fans, control motors and other lightly loaded devices to perform at higher temperatures than ever before.

*TRADE MARK



▲ Unretouched photo of inner ring from BarTemp bearing that ran 2727 hours—1010 hours at 500°F. plus an additional 1717 hours at 575°F. Dark band in raceway is lubricant transferred from retainer.
▼ Excerpts from lab and field test results.

Bearing	Temperature	Speed (RPM)	Hours
SR3HX110	500°F. 575°F.	1,200	2727
SR4HX110	338°F.	10,000	2500+
SR3HX110	392°F.	1,200	1240+
SR3BSSX112	500°F.	4,500	1036+
SR2HX110	575°F.	2,500	1628

NEW DESIGN DEVELOPMENTS

Two design innovations made BarTemp possible—a Barden-developed heat treatment for stainless steel used for the bearing rings, and a new retainer that serves as a dry lubricant and a ball separator. The BarTemp retainer, reinforced Teflon compounded with a solid lubricant, is the sole lubrication required. As the bearing rotates, the balls transfer microscopic particles of the lubricant to the raceways.

TEST RESULTS

In tests by more than 20 precision bearing users, BarTemp bearings in synchros, control motors, blowers, pressure switches, tachometer generators and other lightly loaded devices have operated from 1000 to 24,000 RPM and at temperatures from −100°F. to 575°F. Typical life exceeds 1,000 hours.

PROTOTYPES AVAILABLE

Prototype quantities of seven BarTemp sizes from .3125" to .7874" O.D. are immediately available in angular contact types, open or shielded. For further data and detailed test results, ask for BarTemp Data Sheet B-1.

Barden is a major supplier of miniature, instrument, spindle and turbine bearings volume-produced to ABEC 7 tolerances or better

for reliability...specify

BARDEN PRECISION BALL BEARINGS

THE BARDEN CORPORATION, 208 Park Ave., Danbury, Conn. · Pioneer 3-9201
Western Office: 3850 Wilshire Blvd., Los Angeles 5, Calif. · Dunkirk 5-0034

Illustrated—New 9700 Series
Piggy Back Hydraulic Control Valve
Meets J.I.C. Standards

Look to Logan

the ultimate in hydraulic valve design

FREE SEND FOR THE "LOGAN CALCULATOR"
A gift to you from Logansport Machine Company upon request.

MEMBER: Natl. Mach. Tool Builders Assn.; Natl. Fluid Power Assn.

LOGANSPORT MACHINE CO., INC.
811 CENTER AVENUE, LOGANSPORT, INDIANA

PLEASE SEND COPY OF CATALOG:

- ☐ 100-1 AIR CYLINDERS
- ☐ 100-2 MILL-TYPE AIR CYLS.
- ☐ 100-3 AIR-DRAULIC CYLS.
- ☐ 100-4 AIR VALVES
- ☐ 100-5 LOGANSQUARE CYLINDERS
- ☐ 100-5-1 ULTRAMATION CYLINDERS
- ☐ 51 PRESSES
- ☐ FACTS OF LIFE
- ☐ 62 SURE-FLOW PUMPS
- ☐ 200-1 HYD. POWER UNITS
- ☐ 200-2 ROTOCAST HYD. CYLINDERS
- ☐ 200-3 750 SERIES HYD. CYLINDERS
- ☐ 200-4 and 200-7 HYD. VALVES
- ☐ 200-6 SUPER-MATIC CYLS.
- ☐ 70-1 CHUCKS
- ☐ ABC BOOKLET
- ☐ CIRCUIT RIDER

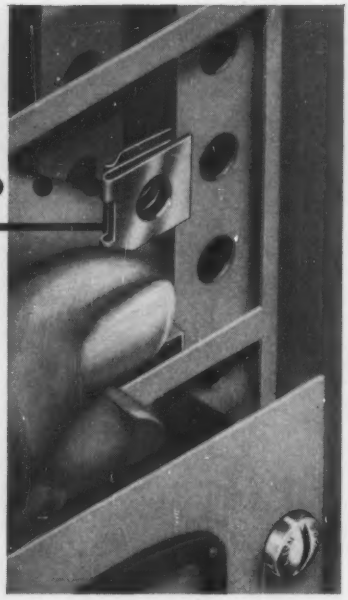
TO:

NAME_____ TITLE_____

COMPANY _____

ADDRESS _____

NEW.



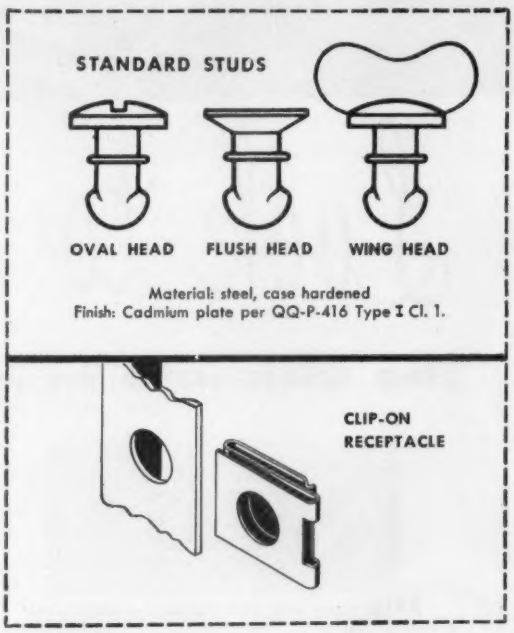
clip-on receptacle cuts 1/4 turn fastener installation time by 86%

for **LION** 1/4 *turn* **FASTENERS**

Riveting and welding are eliminated by the new, time-saving clip-on receptacle that just slips over a hole in your door frame and locks itself in place.

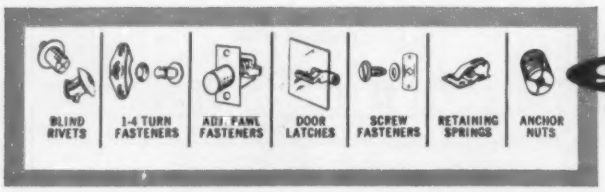
The Lion stud is as easily installed. Slipped through a hole in the panel or door, it is captivated by a split ring retainer. Both the stud and receptacle have a generous "float" to tolerate misalignment of parts.

Operation is fast—1/4 turn to lock, 1/4 turn to unlock.



FREE! For complete information on this and other fasteners, send for your free copy of Southco Fastener Handbook, Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

© 1960

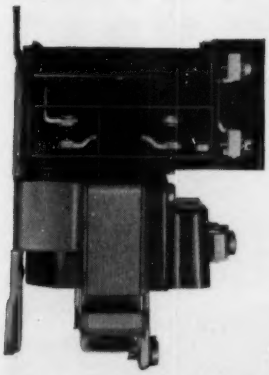


SOUTHCO FASTENERS
LION

How a General Electric CR2810 machine tool relay had . . .

20 MILLION CHANCES TO FAIL

BUT DIDN'T



MORE THAN 20 MILLION TIMES a large automotive body stamping company challenged the General Electric CR2810 machine tool relay to "make" and "break."

It was part of an accelerated life test conducted recently in their own plant to find the most reliable machine tool relay for their continuous production line.

Long after all competitive relays tested had failed, the contacts in the G-E relay were still "making" and "breaking" with continuous reliability. Why? Greater fidelity—made possible by the smooth "wipe and roll" action of the General Electric relay contacts.

OTHER ORIGINAL EQUIPMENT MANUFACTURERS as well as users have proved to themselves the reliability of General Electric relays. For example, after one year's experience with G-E relays, a manufacturer of packaging machinery cut his purchases almost in half. His explanation: "Before I bought General Electric relays, 50 per cent of my purchases were used to replace relays under my maintenance contract." He saved inventory investment and stocking costs. You can too.

Extra reliability is one of the "measurable advantages" of G-E machine tool relays that builds customer acceptance for your products. Add to this the ease of mounting and wiring, the compact design, and the circuit flexibility of G-E relays, and you have a value that can't be matched.

Why not test them yourself? Call your G-E sales engineer at your nearby G-E apparatus sales office. Ask for bulletin GEA-7021. General Electric Company, Schenectady 5, N. Y.

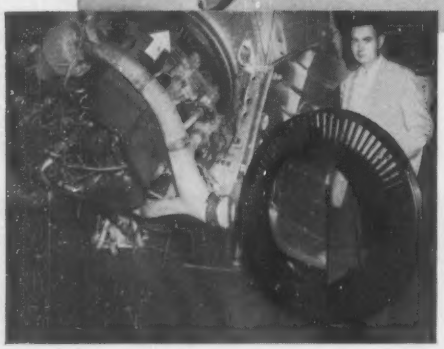
811-13

You get **MEASURABLE ADVANTAGES**
with General Electric Control

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 464 on Page 19

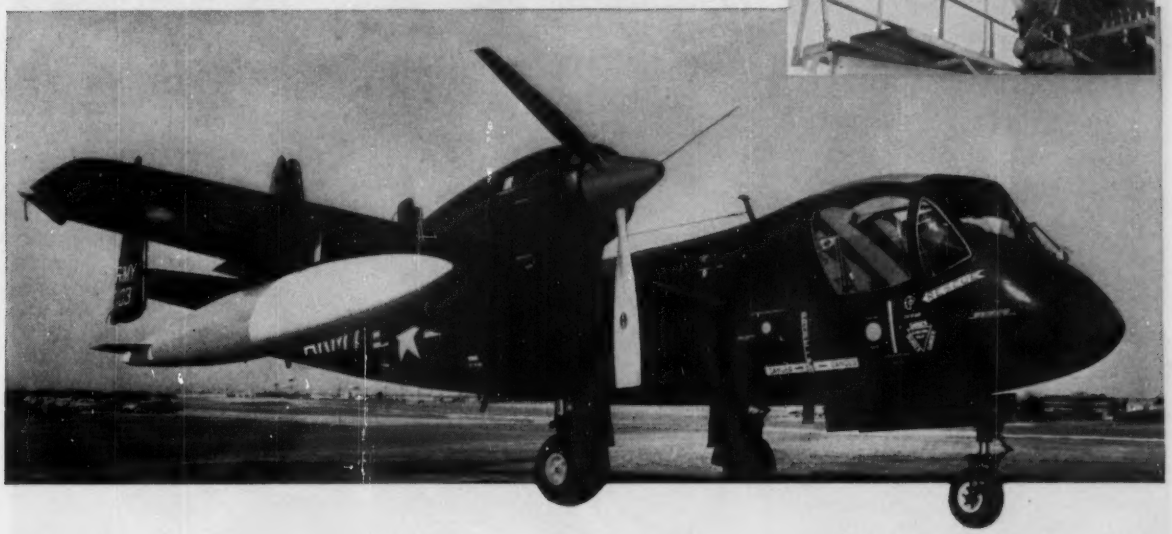


Epoxy resin-glass fiber helicopter part is stronger, lasts 5 times longer than metal. Air deflecting contravanes, mounted directly on the engines of Sikorsky S-58 helicopters, are subjected to engine vibration. Formerly made from metal, such contravanes became inoperative after about 3 million cycles in a test machine. Now, contravanes made of glass fiber impregnated with BAKELITE Brand epoxy resin are being used in this important assembly. Manufactured by the Fibremold Division, Hampden Brass and Aluminum Company, the epoxy-glass combination has exceptional ability to dampen vibration and resist fatigue. Tests show no failures after 15 million cycles! As an extra bonus, the epoxy-glass part cuts weight 11½ per cent.

TO GAIN STRENGTH, REDUCE WEIGHT, SAVE TIME

Epoxy resin-glass cloth laminate saves 80% of cost of large laminating tool. The Tapco Group of Thompson Ramo Wooldridge Inc. has dramatically proved the merits of epoxy-glass laminate tooling. A parabolic-shaped laminating tool about 15 feet long and seven feet across was built of BAKELITE epoxy resins laminated with glass fibers. The big tool, its surface smooth and flawless, was made and placed in production in a minimum amount of time. The company claims this epoxy-glass tool saved them approximately four-fifths the estimated cost of a tool made from other materials.

Epoxy-glass "spinners" dampen vibration, maintain strength despite alternate icing and heating. Predicted long, reliable service life is one of the outstanding features of epoxy resin-glass cloth propeller "spinners" now being used on Grumman "Mohawk" airplanes. The epoxy-glass cloth "spinners" which incorporate de-icers for the aircraft's propellers possess excellent tensile strength and fatigue resistance—very important properties for a part that is subjected to severe vibration. The wire heating elements, that are laminated right in with the glass cloth and impregnated with BAKELITE Brand epoxy resin-based compound, have excellent electrical insulation. The strength-to-weight ratio of the "spinner" is high. In addition, the manufacturer, Fibremold Division, Hampden Brass & Aluminum Company, reports production costs are substantially lower.



...DESIGN IT WITH EASY-TO-FABRICATE EPOXIES

New and practical applications for epoxy resins—often in combination with other materials, such as glass fiber and metal—are being introduced by ingenious designers in many fields. No other resin commercially available offers so many advantages: exceptional strength—stronger than other plastics—even under wide temperature ranges . . . excellent resistance to most chemicals, water and weather . . . ease of fabrication that saves untold hours of production time and costs. Some of the newer applications for epoxy resins include filament winding, electrical encapsulation and embedment, and fabrication of large storage vessels and containers.

For more information about BAKELITE Brand plastics—epoxies, polyethylenes, phenolics, styrenes, and vinyls—mail the coupon today. See Sweet's Product Design File, section 2a/ui, for a list of properties.

BAKELITE and UNION CARBIDE are registered trade marks of Union Carbide Corporation.

UNION CARBIDE

Dept. FH-84, Union Carbide Plastics Company
Division of Union Carbide Corporation
270 Park Avenue, New York 17, N. Y.

Please send me information on BAKELITE resins and suggested applications. I am especially interested in

_____

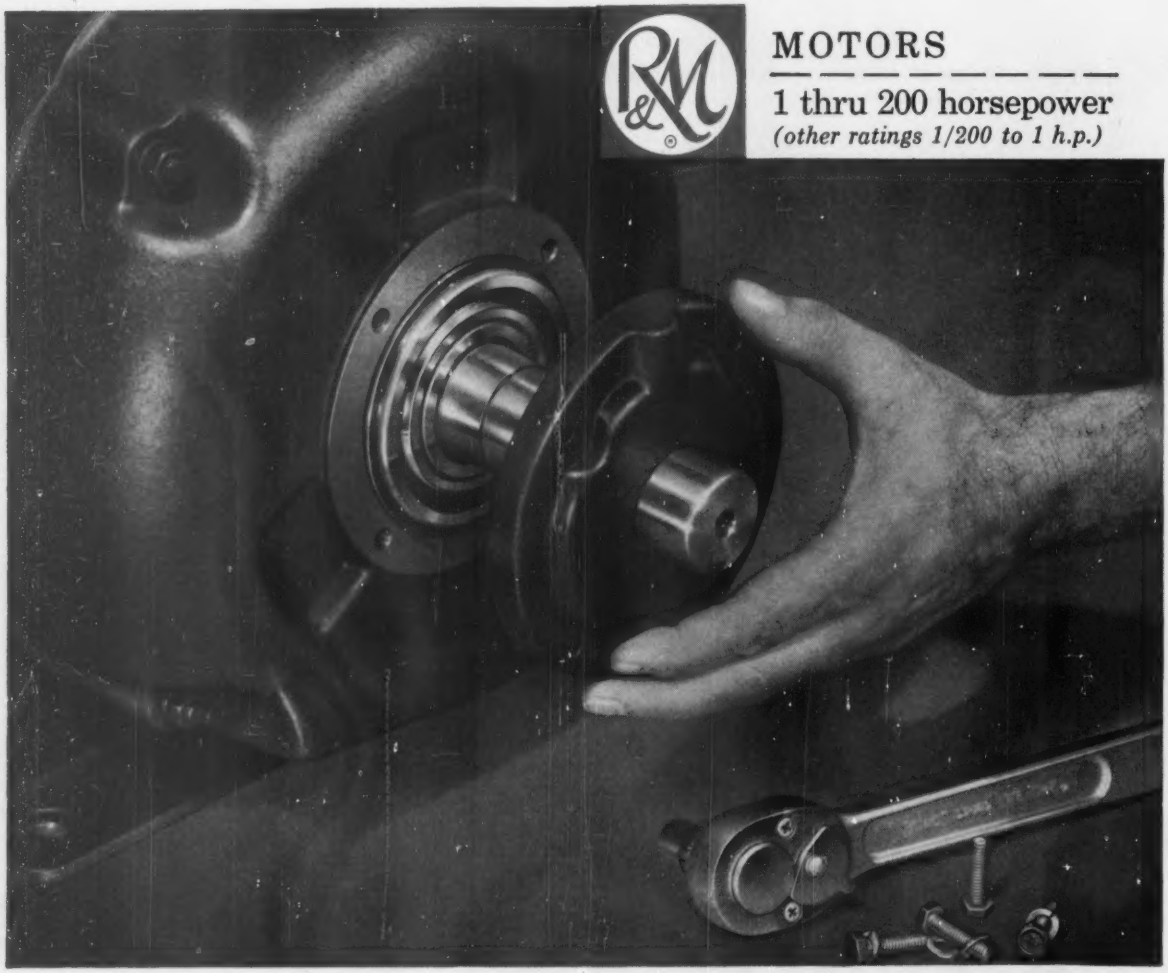
NAME_____

FIRM NAME_____

STREET_____

CITY_____ ZONE____ STATE_____

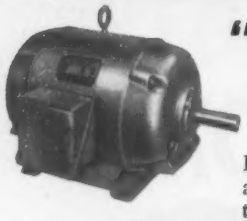
Circle 465 on Page 19



MOTORS

1 thru 200 horsepower

(other ratings 1/200 to 1 h.p.)

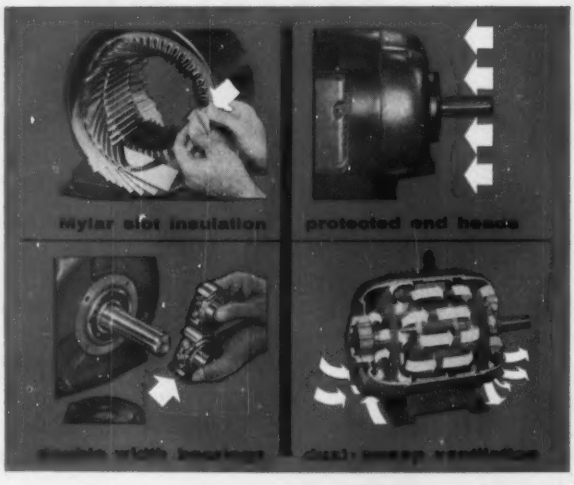


"On-the-Job" Bearing Inspection and Relubrication are Easy!

ROBBINS & MYERS motor bearings are fully sealed and pre-lubricated to operate for years without attention of any kind. However, when maintenance schedules call for bearing inspection and relubrication at shorter intervals, R&M motors cut downtime and save labor expense by making these inspections easy. The bearing cap on each end head comes off quickly when the four securing bolts are removed. The bearing seal, held in place by removable snap rings, likewise, is easily removed to expose the interior of the bearing.

Easily removable bearing caps are only one of R&M's many desirable design features. Double width bearing races have extra-large grease capacity . . . Mylar* insulation that has 8 times the dielectric strength and 35 times more moisture resistance than ordinary paper insulation . . . end heads offer full-height protection . . . dual-sweep ventilation assures efficient cooling. For details, write today for Bulletin 520 MD

**DuPont registered trademark*



ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

Some Ideas

for your file of practical information on graph papers

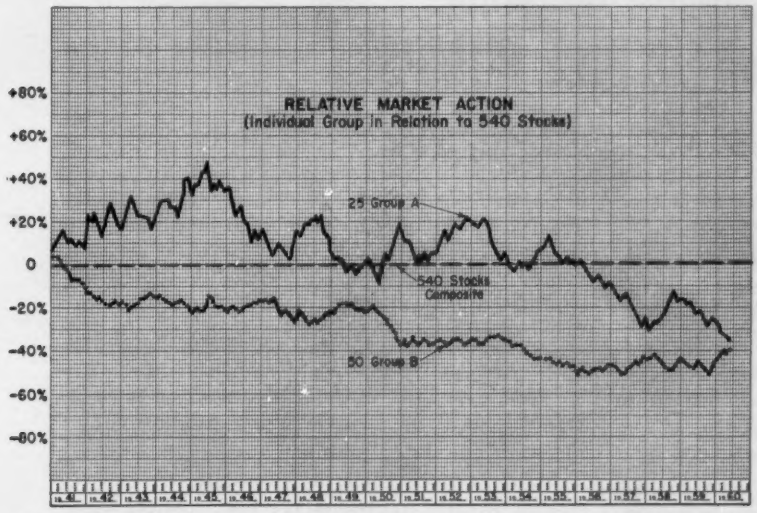
KEUFFEL & ESSER CO.

A graph can be defined as: "A picture of a collection of facts." Often, like that well known Chinese watercolor, a graph is worth a thousand words – or figures. There's no question that graphs speed up comprehension. In some cases, no other way exists to show the subtle interaction of statistics and data except by graph. It's no wonder that legions of engineers, architects, scientists and businessmen rely on graphs and charts to give them the complete information they need.

The big wonder is that more don't know and take full advantage of the fabulous variety of graph papers available from K&E. This is sort of a crusade with us – and has been ever since the turn of the century (a *billion plus* graph sheets ago).

Just The Right Sheet For You

The graph sheet shown below is just one of thousands of job-matched papers made by K&E. These are grids and patterns evolved to solve *specific* needs. The chances are roughly 1000 to 1 that we have exactly the paper you need to chart the statistics of your company or job.



12,300 variables at a glance. Here's a typical stock market chart used to study relative market action. Center line is market behavior of 540 stocks over 20-year period. Two basic stock groups of 25 and 50 individual stocks, averaged, are plotted against market (figured at zero per cent). Resultant chart shows all-important slope of curve which – far more than gross increases – tells the story of the stocks' vitality. No list of statistics, no matter how exhaustive, could give the relative interactions shown here. This picture is possible only with a graph.

But if we don't have what you want – if we lose that 1000 to 1 bet – we'll gladly pay off by working with you to create exactly what you need. We've done this thousands of times for other customers. Just recently it was the U.S. Bureau of Standards. We worked with them to devise two new sheets for recording the complex heat reaction patterns of various insulating materials. These two sheets are already "standards" in the electrical industry.

Choosing That "Right Sheet"

What *is* the graph paper that will do the best job for you? (Actually, there may be more than one – dozens perhaps.) We could answer that here, but we've already done so in a brand new edition of our famed K&E Graph Sheet Catalog. Not only does this catalog guide you in the

selection of the sheets you need, it shows you – often full size, in color – the patterns in question.

We've printed an ample supply of this new catalog, and are prepared to send you your copy *free*. Just return the coupon below.

What Makes Graph Papers Different?

There's a wide gulf of quality in graph papers – more than you'd dream possible. Only the finest sheets can really accomplish the complex, accurate work they're designed for. That's why we build-in three important features:

PRINT. Every K&E Graph Sheet ever made was printed from precision-engraved plates by the *letter-press* process. Offset printing, to our way of thinking, relies unduly upon the vigilance and skill of the printer. Variation from lot to lot is a distinct possibility. We have never taken that chance . . . and we're the *only* manufacturer of graph papers that hasn't.

PAPER. All K&E graph sheets – translucent or opaque – are printed on papers with at least 50% rag content – in some cases 100%. Every square foot of this stock is examined in our quality control labs *before* being sent to the printer. Top grade paper means that adjustment upward in accuracy and long life which is so important to so many people.

PACKAGE. Locating graph sheets can be a chore if they're packaged in old-fashioned boxes or envelopes where you can't see what's inside. Especially true if you use a big variety of sheets. Solution: the new *visual* package offered by K&E. The package has a "window" in front so you can see the sheet inside. In addition, there's a full description of the style, number of grids, line color, type of paper, etc. printed on three sides of the package. Designed to serve as a file folder, the package can be stored flat if desired.

We'd like you to see this new package, and a representative sampling of K&E graph sheets you can more than likely put to immediate use. This too is yours free just for returning the coupon below.

And for all the facts about graph papers, and any other of the 9,000 products made by K&E, see your nearby K&E dealer.

KEUFFEL & ESSER CO., Dept. MD-12, Hoboken, N. J.

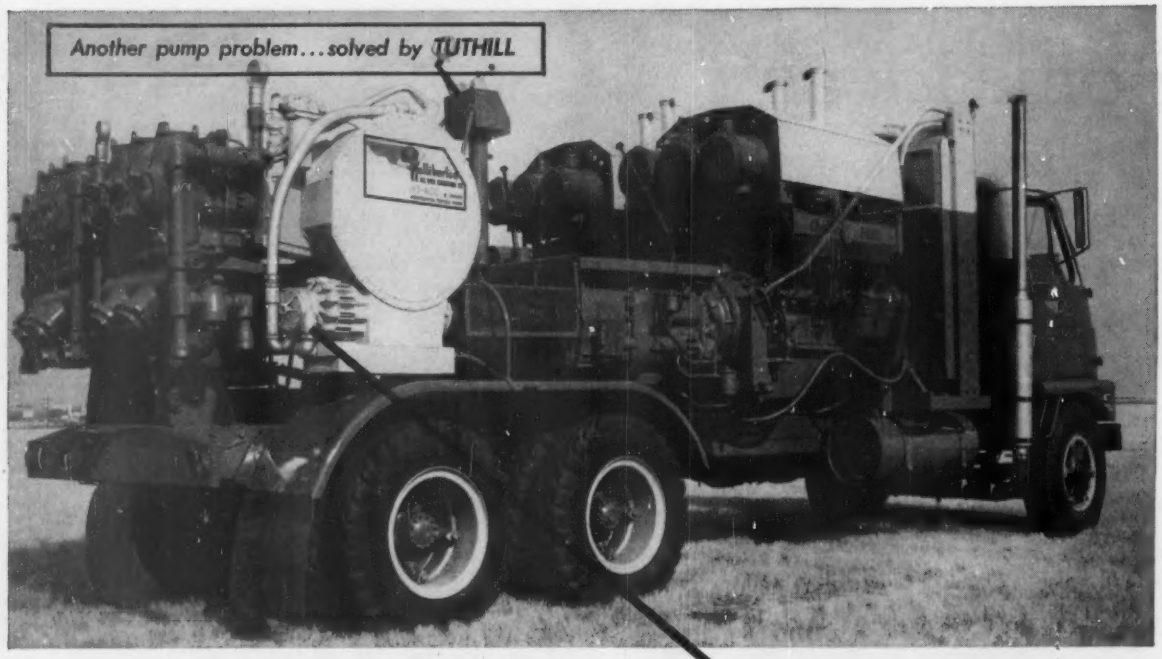
Please send me your new graph-sheet package with samples of K&E graph paper, and the latest K&E Graph Sheet Catalog & Selection Guide.

Name & Title: _____

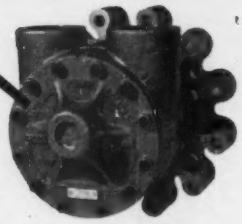
Company: _____

Address: _____

Circle 467 on Page 19



POSITIVE LUBRICATION of Halliburton "fracturing" units with TUTHILL PUMPS



The HT-400 truck mounted pumping unit is a proud manifestation of Halliburton's 35 years of leadership in oil field service operations. These units were especially developed for "fracturing" . . . the breaking apart and propping open of oil formations by hydraulic or fluid pressure . . . in which oil mixed with selected grades of sand is pumped into oil wells at extremely high pressures. A pair of HT-400 units, mounted side by side, can deliver over 1,000 hydraulic horsepower . . . move over 42 barrels of oil per minute . . . or, with modifications, reach pressures of 20,000 psi.

For positive lubrication and cooling Halliburton selected Tuthill model 6C pumps as an important component of the rugged HT-400. Special modifications of the shaft and mounting bracket by Tuthill's application engineers permit the 6C to be assembled into the Halliburton unit with the greatest possible ease.

Over 800 standard models

This model 6C is one of over 800 models in Tuthill's complete selection. These include reversing pumps, special pump motor-combinations, and stripped units for OEM use. They may be furnished with a wide variety of modifications including built-in relief valves, automatic reversing feature, special porting arrangements, special seals or shaft extensions, and many more.

Probably a Tuthill standard model can provide an economical, dependable answer to your pumping problem. But if your application requires it, Tuthill's engineers will develop modifications or special features to provide the best possible solution to your pumping problem.

Catalog 100 describes the complete Tuthill line. Write for your copy. Or forward information on your application, so we can indicate how our engineers may be able to provide savings.

Tuthill manufactures a complete line of positive displacement rotary pumps with capacities from ⅛ to 200 gpm; for pressures to 1500 psi; speeds to 3600 rpm.

PUMPS FOR YOUR PURPOSE

TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois

Circle 468 on Page 19

The new LICON® line . . . precision switches for every need

In the new, broadened Licon line you'll find every switch designed to meet modern high capacity, long life requirements. These are switches built to do today's tough jobs. Typical is the unique Type 16—heart of many Licon switch assemblies—tiny in size but rugged enough to handle big switch loads with unbelievable life. Check the unusual "specs" of the Type 16, and all Licon types, against your switch needs—see and compare Licon life against any switch—we're sure you'll specify Licon. *Send for catalog on new broad* **Licon** *line*

—Gives handy dimensional data and engineering specifications you'll want to keep for ready reference.

Type 30 Enclosed Limit Switches—Interchangeable components form up to 18 switch types for quick replacement. High quality, compact, low-priced. 15A., 125V a-c—for industrial applications.

H—Hermetically sealed Switches—Designed for dependability in extreme environments. Unique, true hermetic sealing against dust, moisture and other elements. Designed especially to your application.

Type 14 Heavy-duty Switch—Built for heavy industrial and machine tool service. Rugged snap-action has large contacts rated 20 amps at 250V a-c.

Type 10 Long-life Basic Switch—New Serpentine action mechanism delivers 10 million operations without failure. Can be provided with movement differentials as low as .0005". Rated 15 amps.

Type 22 Double-pole, Double-throw Switches—Provide positive control of four independent circuits. Simplifies controls for multiple circuit applications—withstands 25G at 2000 cps. Rated 15 amps., 125/250 V a-c, 30V d-c (res.).

P—Panel mounted Switches—Variety of types—to 8 or more poles—some solenoid reset or magnetically held—sealed and unsealed as required.

Type 11 Snap-action Switches—Resist 50G vibration to 2000 cps. Double-break, snap-action design eliminates dead break, contact welding and provides greater capacity. Rated 10 amps., 125/250V a-c, 30V d-c.

Type 16 Subminiature Switches—Here's big-switch performance in a tiny unit. Only ½" thick, 25/32" long—yet rated 10 amps, 28V d-c ind. Greatest shock- and vibration-resistance of any switch in its class on the market . . . even near trip point.

LICON

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Available through your local Licon distributor.

DIVISION OF ILLINOIS TOOL WORKS

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Available NOW...ready to attach S.S. White Standard Flexible Shafts

A complete flexible shaft package is available *in stock*... ready to attach to your mating spindles ...S. S. White *standard* flexible shafts.

Use them to simplify existing equipment or to make low-cost tests on prototypes. You are ahead of the game with standard flexible shafts, because the designing has already been done for you by S. S. White, first name in flexible shafts.

You can get them in a hurry too. S. S. White carries a complete stock in shaft sizes from .150" to .500" in diameter. *Power drive* flexible shafts for high speed, continuous operation... or *remote control* shafts for operation in either rotational direction. Rugged neoprene casings and standardized couplings that eliminate the need for special connectors.

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THE S. S. WHITE FLEXIBLE SHAFT HANDBOOK
New 4th Edition... Send for your free copy!
This authoritative handbook has been recently revised to include new selection and application data for S. S. White Standard ... Pre-engineered ... Custom-designed flexible shafts.

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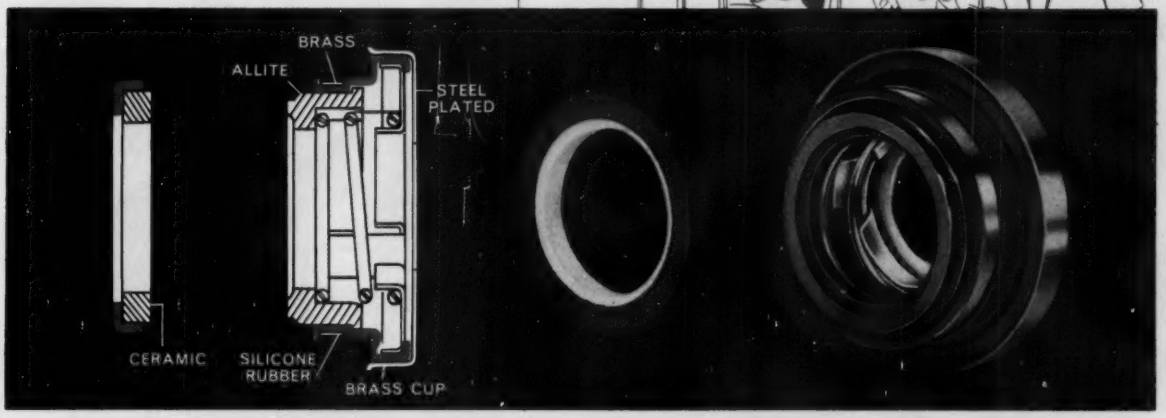
FIRST NAME
IN FLEXIBLE SHAFTS

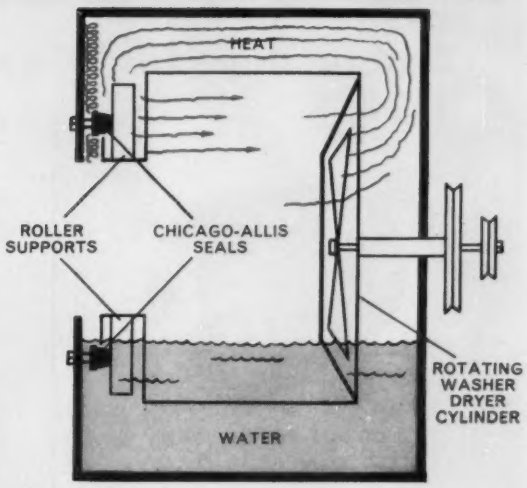
Happy wash days depend on round the clock sealing action



CHICAGO-ALLIS SEAL DESIGN RESISTS HEAT, WATER, SOAP, DETERGENTS AND DIRT... SEALS GREASE IN ROLLER BEARINGS FOREVER

When assigned the engineering task of designing a lifetime seal for a nationally known washer-dryer machine product, Chicago-Allis came up with the right answer pronto. The C-A seal protects bearings in rubber rollers which support the rotary washer-dryer cylinder. Rubber component parts in the C-A seal are molded of silicone and resist heat up to 240° F. Spring loading of the surface sealing elements (Allite and Ceramic), creates a life-long water and grease tight seal.

A typical example of how Chicago-Allis meets specialized needs in mechanical seals and custom molded rubber parts.



Four mechanical seals are used in this washer-dryer application—two of which must operate *under water* during the washing cycle, and all are exposed to extreme heat during the drying cycle.

Send for complete information on all Chicago-Allis products and services.

"Chicago-Allis Engineers to your Specifications"

SINCE 1889

CHICAGO-ALLIS MFG. CORP.

Producers of CHICAGO BELTING · ALLIS RUBBER · ALLIS SEAL Products

127 NORTH GREEN ST. CHICAGO 7, ILLINOIS

Engineers · Designers · Manufacturers

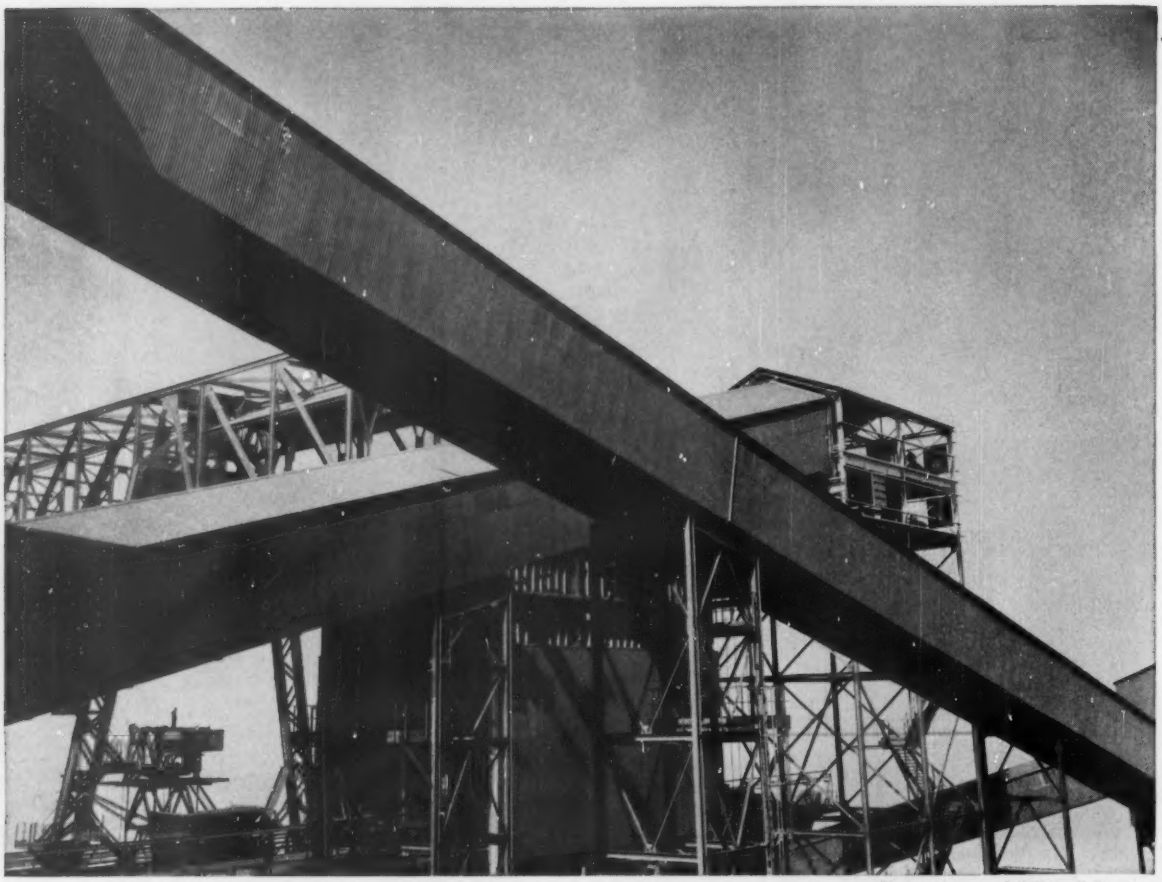
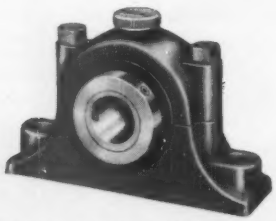


Photo courtesy of McDowell Co., Inc.

Dodge dependability built into sinter plant conveyor system at Inland Steel

DODGE TAPER-LOCK STEEL CONVEYOR PULLEYS



DODGE DOUBLE INTERLOCK PILLOW BLOCKS WITH TIMKEN BEARINGS

Dodge Taper-Lock Steel Conveyor Pulleys and Dodge Double Interlock Pillow Blocks with Timken Tapered Roller Bearings contribute their dependability to this new sinter plant. They are an important part of the extensive conveyor system engineered by Dwight-Lloyd Division of McDowell Company, Inc., Cleveland.

Maximum strength with minimum weight is provided by these rugged conveyor pulleys. Their steel rims, discs and hubs are fused together into jointless drum construction for terrific impact resistance. With the unsurpassed holding power of Taper-Lock mounting there is no "walking on the shaft."

Dodge Double Interlock Pillow Blocks (with Timken Tapered Roller Bearings) were chosen for this hard service. They are rugged, compact, fully self-aligning—with substantial radial and thrust capacities. The extra long inner race distributes load over a greater shaft area. They are adjusted, lubricated and sealed at the factory—for a long life of dependable service.

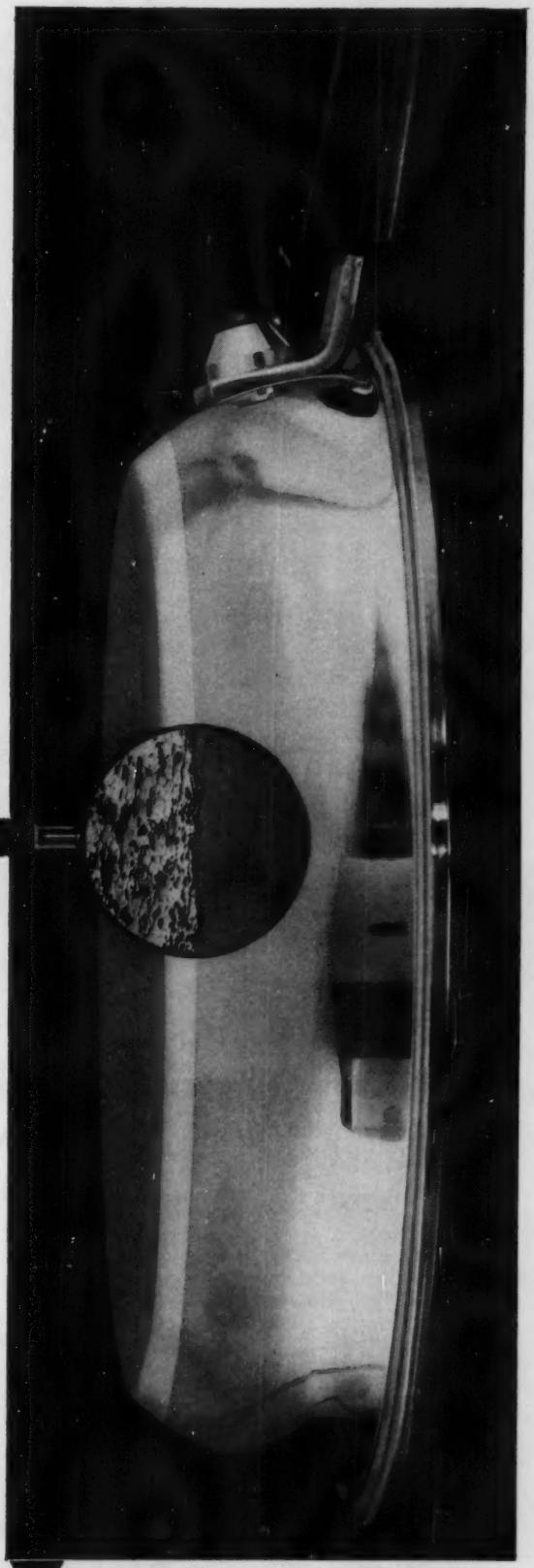
DODGE MANUFACTURING CORPORATION, 3300 Union St., Mishawaka, Ind.

DODGE

of Mishawaka, Ind.

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the white pages of your telephone directory, or in the yellow pages under "Power Transmission Equipment."

Alcoa pressure-bonds ALUMINUM TO STAINLESS for the advantages of both!



Buckeye Division of Mardigian Corporation designs fast, even heating—easy cleaning into its new "Cordon Bleu" cookware line

Alcoa pressure bonding inspired an entirely new line of quality cookware by the Buckeye Division of Mardigian Corporation. "Cordon Bleu" gains the advantages of *both* metals: aluminum's high conductivity, corrosion resistance and light weight; the strength and density of stainless.

Heat and pressure combine to adhere aluminum to stainless in a die without flux or molten metal. The result is a bond of strength, ductility and integrity.

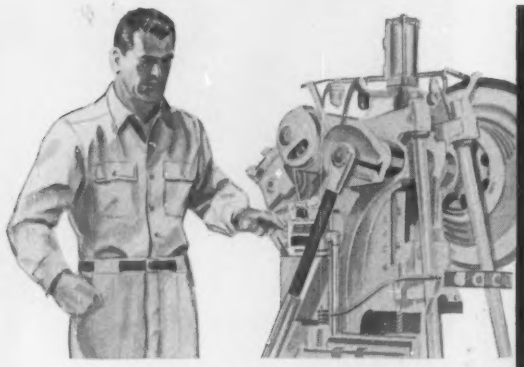
Alcoa's patented process forges many bimetallic unions: aluminum to carbon and alloy steels, to copper, to alloys of itself. Complex shapes are no longer a problem. Here disks cut from aluminum plate flowed up and around radii during bonding. Other processes start with cast aluminum slugs.

Design possibilities abound for this unique pressure-bonding technique. Want more data, design help, feasibility evaluation? Call on your nearest Alcoa sales office, or write: Aluminum Company of America, 905-M Alcoa Building, Pittsburgh 19. Pa.

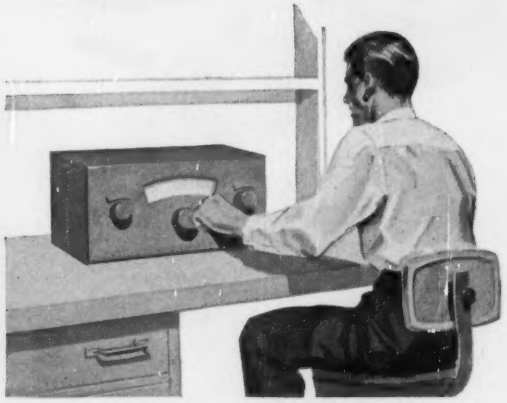
ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA

Reduce down time... *Locate trouble faster with an ACRO-LITE Metal Clad Switch*



DIRECT MOUNT



REMOTE MOUNT

Acro-Lite
METAL CLAD SWITCH

for original equipment

Choice of 5 Actuators

For Direct Replacement

INTERCHANGEABLE WITH YOUR PRESENT SWITCH OF THIS SHAPE.

Distributors in more than 100 cities

- The Acro Lite can be wired to indicate if power to the switch is "on" or "off".
- The neon light element of the Acro Lite switch can be placed on either side or on the bottom of the switch.
- The internal switch is replaceable without removing the metal housing from its mounting.
- One standard Acro precision snap action switch is used internally for all Acro Lite metal clad switches.
- The Acro Lite is listed for 21 amperes at 120, 240, or 480 V.A.C.; 1 HP at 120 V.A.C. and 2 HP at 240 V.A.C.
- A selection of five mounting holes makes the Acro Lite metal clad switch interchangeable with most switches of the same type.
- The Acro Lite switch is designed to be used for either right or left hand mounting.

Application Engineers available in principle cities throughout U. S.
In Canada, contact Robertshaw-Canada 580 Evans Ave., Toronto, Canada

Robertshaw
MR. CONTROLS
ACRO DIVISION
COLUMBUS 16, OHIO

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WEAR RESISTANT
THOMSON

60 Case

AVOID the HIGH COST and difficulty of fabricating long, hard & straight parts by conventional methods!

hardened and ground

SHAFTS, ROLLS, GUIDE RODS and other long-round parts

ELIMINATE WEAR and REDUCE COST

60 Case is the result of over 15 years of experimental work and production experience with hardened and ground shafts which are a requirement for BALL BUSHINGS, the Linear Ball Bearing manufactured by Thomson Industries, Inc.

The special techniques and equipment that have been developed enable high production rates and low handling costs. This permits big savings over conventional methods which are plagued with erratic warpage, straightening and resultant grinding problems. Finished *60 Case* parts frequently cost less than the scrap losses that result from conventional methods.

60 Case material has a surface hardness close to 60 on the Rockwell C scale which is essential to resist wear.

Long lengths of material ranging in diameter from ¼" to 4" are stocked to enable prompt shipment of *60 Case* parts, with or without special machining. *Write for literature and name of your local representative.*

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ADVANTAGES of *60 Case*

- COST REDUCTION
- HARD BEARING SURFACE
- NICK-& DENT-PROOF
- ACCURATE DIAMETERS
- GROUND FINISH
- STRAIGHT PARTS
- DELIVERY FROM STOCK
- ADDED STRENGTH
- UNIFORM HIGH QUALITY

TYPICAL *60 Case* PARTS

GUIDE RODS • SHAFTING • ROLLS • TRAVERSE RAILS
PISTON RODS • ARBORS • LEADER PINS • TIE RODS
KING PINS • AXLES • CONTROL RODS • GUIDE POSTS
MANDRELS • BEARING ROLLERS • SPINDLES

THOMSON INDUSTRIES Inc.
Dept. C-5, Manhasset, New York

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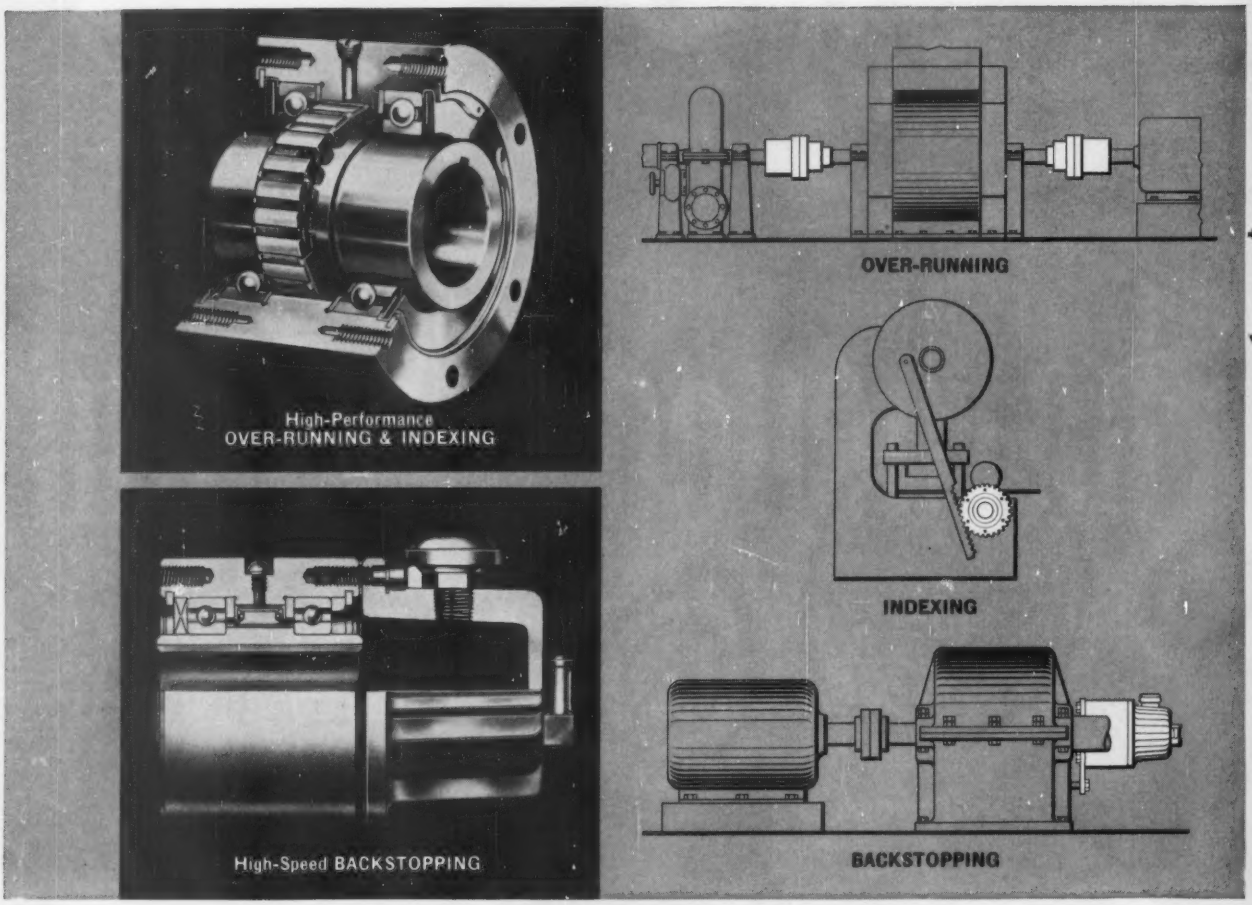
PARTS HARDENED to 60 C...
increase life...reduce cost!

FORMSPRAG Clutches have



These Installations Prove Formsprag Has The Most Advanced Clutch Designs Available

On tough applications requiring high-performance over-running, indexing or backstopping, Formsprag clutches have *proved* their unusual durability, precision and reliability. Their long-life and minimum maintenance requirements, even under unusually demanding installation conditions, have provided many users with the answer to their clutch problems. Compare the following performance results on actual installations—Formsprag designs can help you, too!

High-Performance Over-Running

Application:
Forced and Induced Draft Fans.

Clutch and Mounting:
Model FO-732 Clutch-coupling (HPO-720 clutch with coupling) mounted on fan drives.

Requirements:
Continuous over-running at 1200 to 1800 R.P.M. (24 hours a day, 365 days a year).

Proved Results:
The Formsprag HPO clutch design with Formchrome sprags provides this company with greater durability and less maintenance than any other available clutch. Therefore, on all forced and induced draft fans, this manufacturer specifies Formsprag high-performance over-running clutches.

Precision Indexing

Application:
High Speed Press.

Clutch and Mounting:
Model HPI-700 feeding a progressive die.

Requirements:
20° indexing; feed is 700 strokes per minute; accuracy of feed must be within .005"; press operates 24 hours a day, 5 days a week.

Proved Results:
After poor service life and unreliable results from other clutch designs, a Formsprag high-performance indexing clutch was installed. Result—customers requirements for accuracy were met, clutch has had a life of 80 million cycles, and is still running.

proved higher performance

(GREATER TORQUE & SPEED, HIGHER PRECISION, LONGER LIFE)

During the last two years, Formsprag has announced several major advances in over-running clutch design. These advanced concepts have been widely accepted by designers of modern power transmission systems. The high performance results they obtained on over-running, indexing and backstopping applications *prove* Formsprag clutches to have the most advanced designs available.

On-the-job records *prove* these high performance characteristics: (1) Formchrome sprags, with high-hardness and wear resistance, provide exceptional durability—no other manufacturer can offer the performance advantages of Formchrome sprags. (2) The improved sprag and retainer design of Formsprag High-Performance Over-running (HPO) and Indexing (HPI) clutches permit up to 30% higher operating speeds with same life span and up to 70% longer clutch life when operated at same RPM as ordinary clutches. (3) On backstopping applications, the High-Speed Backstopping (HSB) clutch design permits higher speeds, assures longer life and reduces maintenance to a minimum.

Specific case-history data on *proved* over-running, indexing and backstopping installations is provided below. In every instance, users of Formsprag High-Performance Clutches have found the answers to problems of wear, high-speed operation, precision and maintenance.

There is a Formsprag Clutch for every application. Standard models include: sleeve bearing, ball bearing, miniature, large-bore holdbacks, and high-performance types. For special applications, Formsprag engineers will recommend a modified standard clutch or design a special. Standard clutches are fully described in the Formsprag catalog—send for your free copy.

FORMSPRAG COMPANY

23603 Hoover Road, Dept. 114-A — Warren (Detroit), Michigan

Representation Throughout The World • Precision Power Transmission Products

High-Speed Backstopping

Application:
Iron Mining (Taconite) Conveyor.

Clutch and Mounting:
Model HSB-700 clutch assembly mounted on high-speed shaft of reducer.

Requirements:
In abrasive atmosphere, clutch must over-run at 1200 to 1800 R.P.M. (24 hours a day, 9 months of year).

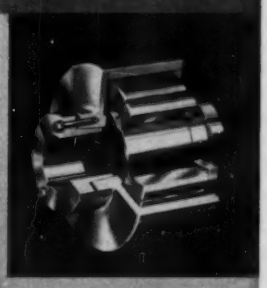
Proved Results:
On this rugged backstopping application, Formsprag HSB clutches solved problems of overheating, premature seal wear, and short clutch life. These high-speed backstopping clutches have been in operation for over a year and are still delivering their initial high performance.

OTHER FORMSPRAG PRECISION PRODUCTS

NEW RAWSON

CENTRIFUGAL CLUTCHES and CLUTCH-COUPLINGS

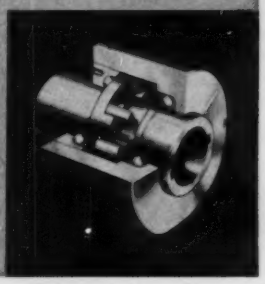
Used in a wide variety of applications, the Rawson design provides no-load starts for motors and cushioned starting of driven equipment. They permit using smaller motors and across-the-line starting.



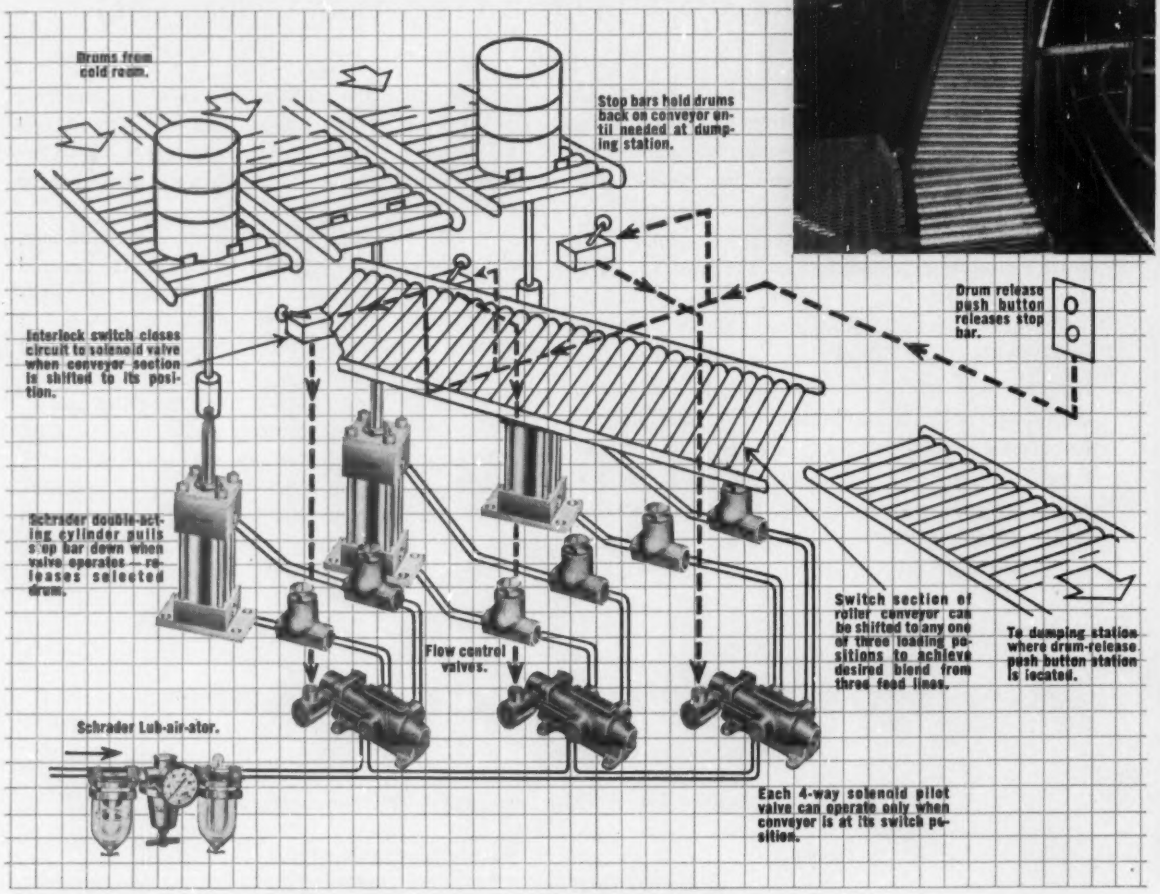
REVLOK

DUAL TORQUE-LOCKING and POSITIONING DEVICES

These multi-purpose devices stop feedback torque and provide two-directional positioning, over-running, backstopping and load-limiting. They can also be adapted for single revolution and torque-limiting functions.



Processors automate even heavy work with air. In a complex frozen juice concentrate blending operation, Plymouth Citrus Products Cooperative, Plymouth, Fla., hooks up Schrader Air Products simply and economically to a gravity conveyor. Full 55-gal. barrels on feed sections roll down to stop bars and are selected in correct order and ratio for dumping. "The Schrader system performs well," says C. Byron Smith, plant manager. "We're handling 200 to 300 barrels a day on this selective conveyer, and could handle more."


Drums from cold room.
Stop bars hold drums back on conveyor until needed at dumping station.
Drum release push button releases stop bar.
Interlock switch closes circuit to solenoid valve when conveyor section is shifted to its position.
Schrader double-acting cylinder pulls stop bar down when valve operates — releases selected drum.
Flow control valves.
Switch section of roller conveyor can be shifted to any one of three loading positions to achieve desired blend from three feed lines.
To dumping station where drum-release push button station is located.
Schrader Lub-air-ator.
Each 4-way solenoid pilot valve can operate only when conveyor is at its switch position.

PROCESSOR AUTOMATES BACK-BREAKING CHORE WITH SCHRADER AIR PRODUCTS . . . GAINS SPEED, EFFICIENCY, BIG ECONOMIES

Solve difficult problems of handling, conveying and sorting, just like this company . . . with air! Versatile Schrader Air Products take punishing environments in stride, even corrosive atmospheres . . . Work together like magic on American production systems of many different kinds in hundreds of industries.

You already have air. Add Schrader Air Products to push, pull, hold, position, move work repetitively . . . cure headaches of weight, assembly, production maintenance . . . perform tirelessly and with precision. Speedy yet safe Schrader takes the drudge out of work, adopts to special needs, saves time, money and effort.

Select from the full Schrader lines to plan your automation of machines. Your Schrader distributor can help you pinpoint what you need. For more data write:

Schrader®
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Division of Scovill Manufacturing Company, Incorporated
476 Vanderbilt Avenue, Brooklyn 38, N. Y.

QUALITY AIR CONTROL PRODUCTS

Circle 477 on Page 19

Another example of how

You Fill Out The Tag...

You can choose your own performance features when you order a Fenwal 536 Temperature Controller. And get them in a *compact, low-cost, transistorized stock instrument!*

Basic member of Fenwal's new "500" family, the "536" *always* provides precise control action. You merely select from the following features to meet your specific needs: 1. Proportioning or On-Off Control. 2. Five standard temperature ranges from −50 to +600°F (Special ranges, expanded scales, and centigrade scales available). 3. Dial for set-point adjustment externally or internally mounted. 4. Separate potentiometer with graduated dial and knob for remote adjustment. 5. Cartridge, hex head, flange or coupling head probe for thermistor sensor. All configurations have a rating of 10A-115VAC or 5A-230VAC. *You buy exactly what you need!*

Of course, for the user who needs most of these features, it may make more sense to order a Fenwal 561 Indicating Controller . . . with indication as a *plus*. And for multi-point indication, as many as ten 536's can be plugged in to a 580 indicator. Get catalog on the complete "500" Line. Write FENWAL INCORPORATED, 1914 Pleasant Street, Ashland, Massachusetts.

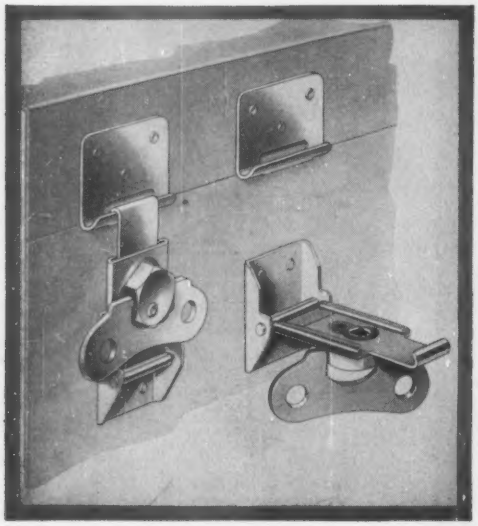
Fenwal CONTROLS TEMPERATURE . . . PRECISELY

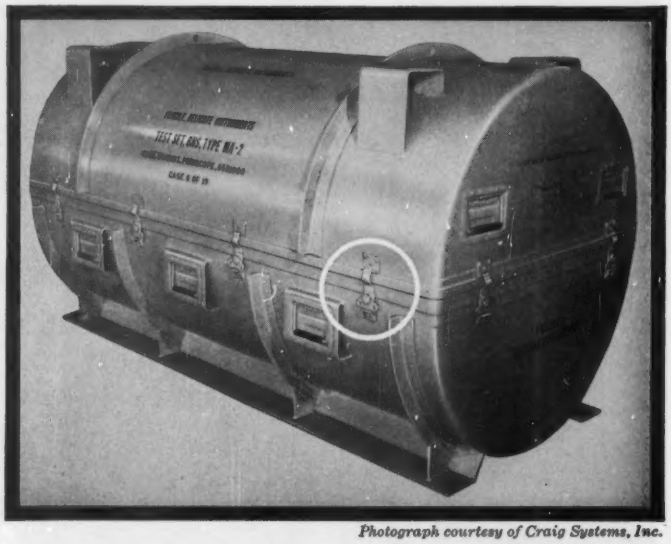
Circle 478 on Page 19

Note—Commercial and Military Packaging Engineers:

Rugged LINK-LOCK

...your best answer to exacting closure problems





Photograph courtesy of Craig Systems, Inc.

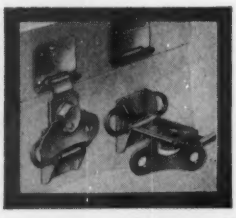
LINK-LOCK provides pressure-tight closure on this rigidly specified equipment container

Simmons LINK-LOCK provides quick opening and closing as well as impact-resistant dependability on transit cases manufactured by Craig Systems, Inc., Lawrence, Mass.

The cylindrical Craig container above is gasketed and pressure-tight, and contains delicate electronic equipment. Twelve LINK-LOCK fasteners are used on this model.

Here's why LINK-LOCK is ideal for use on military cases produced to exacting specifications as well as on inexpensive commercial containers:

- Impact and shock resistant (positive-locking).
- High closing pressure with light operating torque..... insures pressure-tight seals where required.
- Available in 3 sizes, for heavy, medium, and light duty.
- Compact design...lies flat against case even when unlocked.
- Opening and closing by wing-nut, screwhead, or hex nut.
- Flexible engagement latch design...can be varied to suit different conditions.



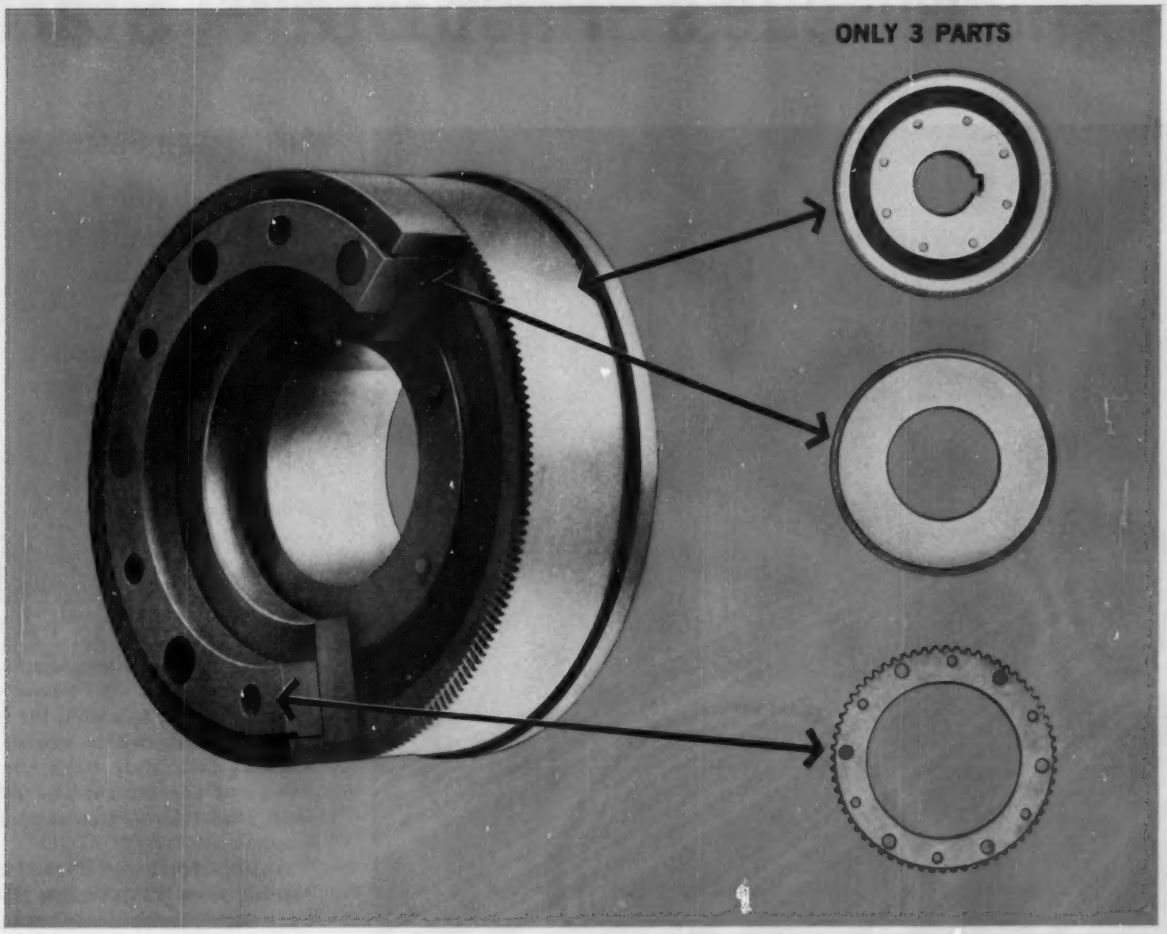
Also available: Spring-Loaded LINK-LOCK. Ideal for the less expensive containers where costs won't permit precision production. Spring provides take-up to compensate for set in gasketing, irregularities of sealing surfaces, and mounting inaccuracies.

Where does the versatile Simmons LINK-LOCK belong in your design? For complete information and specifications, send for the Simmons Catalog today. Samples and engineering service available upon request.

SIMMONS
FASTENER CORPORATION
1756 North Broadway, Albany 1, New York

QUICK-LOCK • SPRING-LOCK • ROTO-LOCK
LINK-LOCK • DUAL-LOCK

See our 8 page catalog in Sweet's Product Design File

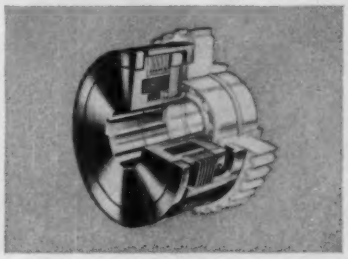


Simplified design means more dependable performance

BENDIX ELMAG *(Electromagnetic)* TOOTH CLUTCH

With only three parts, the Bendix® Elmag tooth clutch provides a simple, positive, compact clutch package for machine designers. The Elmag offers greater torque transmittal than other clutches of the same size. This means you can design for either greater machine capacity or space savings—or both.

For the end user, the Elmag offers the following dependable performance features. There is absolutely no idle torque—no connection between driving and driven members once disengaged. The Elmag can be disengaged under full load at any RPM, and engagement at relative speed is possible. The clutch's simple, bolt-on design makes it easy to mount; there are no additional splines or springs, no external disengagement mechanism. Elmag tooth clutches are designed to perform in either wet or dry applications. They are available from stock in torque capacities ranging from 40 to 4,000 ft.-lbs.



BENDIX ELMAG MULTIPLE DISC CLUTCH—Ideal for step-by-step acceleration of large masses. Disc stack is magnetically isolated. Wet or dry operation. Slip ring or stationary field design. Torque capacities: 10 to 16,000 ft.-lbs.

For full details, write

Bendix-Elmira
Eclipse Machine Division
Elmira, New York

THE Bendix CORPORATION

Circle 480 on Page 19

Missile's "Fast Draw" Starts

Cold-drawn Seamless Cuts Clean-up Costs For Anker-Holth's Power Cylinders

The Missile Age version of the "fast draw" starts with the lightning stroke of a power cylinder.

Big, 12-foot stroke hydraulic cylinders provide the power and speed that unsheath one of the nation's principal defense missiles for instantaneous action.

They're made by Anker-Holth Division of The Wellman Engineering Company from Pittsburgh Steel Company's commercial quality, carbon steel, Seamless Mechanical Tubing.

Mounted two to a unit, the husky cylinders must—within seconds, and without fail—slide back the two halves of the hangar-size missile shelter to release the weapon for firing.

Anker-Holth, of Port Huron, Mich., uses Pittsburgh Steel's Seamless Mechanical Tubing to manufacture this critical unit's outer cylinder and piston rod.

Relies on Pittsburgh—What makes this company rely on Pittsburgh Steel for the tubing it requires for this application?

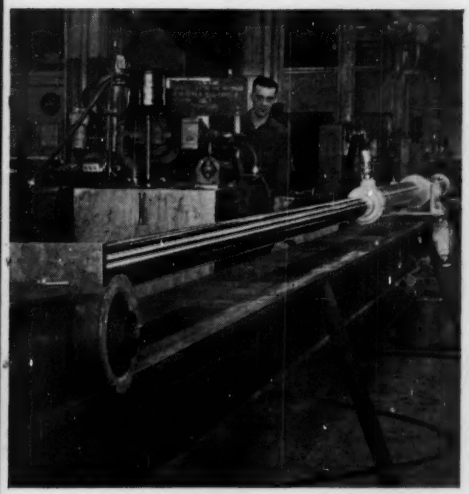
Fred J. Theisen, vice president-production, says there are several reasons. He explains:

"First is Pittsburgh Steel's service. They're able to give us information fast.

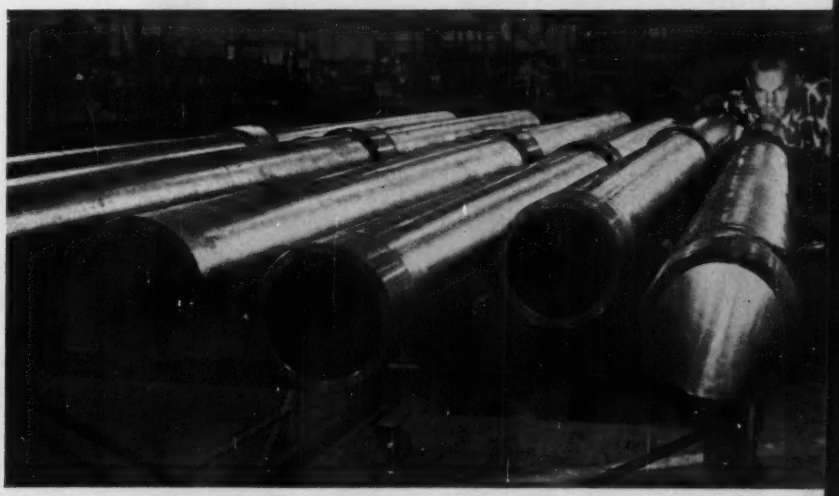
"On the first lot of tubing for this job, we asked all our suppliers for recommended sizes for cleanup to our finished dimensions. Pittsburgh

Piston rod made by Anker-Holth for launcher shelter's roof activating cylinder requires only minimum processing for cleanup with commercial quality Pittsburgh Steel Seamless Mechanical Tubing. Finished rods, 142" long, are plated with hard chrome. Vice president-Production Fred J. Theisen, (left) talking with Pittsburgh Steel salesman T. J. Whan, says Anker-Holth relies on Pittsburgh Steel tubing for this missile component.

With Pittsburgh Steel's Tubing



Final hydraulic testing on completed cylinders is comprised of 30 cycles at 4,500 psi—using special Anker-Holth testing equipment.



Fast service, straightness, and minimum stock removal convinced Anker-Holth that "Pittsburgh was best we could get for this job." Cylinder measures 5 inches by 4 inches by 143 inches. Anker-Holth specializes in power cylinders with bores from one to 48 inches, and strokes to 45 feet.

Steel's answer was in first, and it suggested less stock removal.

"That's important, and it's one reason Pittsburgh Steel stays with us. We ask them for size recommendations that we need for cleanup. They tell us the size, and they do it in a hurry. They don't wait around for a couple of months to reply.

"For another thing, when we first started production of this cylinder, we had a problem of straightness.

"I don't know how they did it, but Pittsburgh Steel came through with a batch of tubing I had never seen the equal of. Pittsburgh makes a quality tube. Straightness is the big thing—plus service and the amount of stock we must remove. With Pittsburgh Steel Seamless Tubes we don't need extra metal for honing—so we aren't paying for metal we don't use."

Experience Pays—Close attention to customers' needs and experience, plus steelmaking skills and production practices developed in nearly 50 years of seamless tube production, make Pittsburgh Steel able to serve Anker-Holth this way.

In this instance, Pittsburgh Steel's ability to produce commercial quality cold-drawn seamless mechanical tubing to exacting standards for straightness, concentricity and tolerances, allows Anker-Holth to simplify its cleanup process of the cylinder's ID and centerless grinding of the piston rod's OD.

Machinability and weldability of Pittsburgh Steel's tubing are vital factors in Anker-Holth's production, too, because plugs, ports, sleeves, piston and end covers are threaded and/or welded to the piston rod and cylinder in this application.

Contact one of the distributors or district sales offices listed below. Then let Pittsburgh Steel Company demonstrate its ability and readiness to help. You, too, will find that Pittsburgh Steel's tubing is the best you can get.

Pittsburgh Seamless Distributors

Baker Steel & Tube Company
Los Angeles, California

Chicago Tube & Iron Company
Chicago, Illinois

Cleveland Tool & Supply Co.
Cleveland, Ohio

Drummond, McCall & Co., Ltd.
Montreal, Quebec, Canada

Edgcomb Steel Company
Philadelphia, Pennsylvania

Gilmore Steel Corporation
San Francisco, California

Earle M. Jorgensen Co.

Kilsby-Tubesupply, Division of
Republic Supply Co.
of California
Los Angeles, California

Mapes & Sprowl Steel Co.
Union, New Jersey

Metal Goods Corporation
St. Louis, Missouri

Miller Steel Company, Inc.
Hillside, New Jersey

A. B. Murray Co., Inc.
Elizabeth, New Jersey

C. A. Russell, Inc.
Houston, Texas

Ryerson, Joseph T. & Son, Inc.

Solar Steel Corporation
Cleveland, Ohio

Standard Tube Sales Corp.
Brooklyn, New York

Steel Sales Corporation
Chicago, Illinois

Tubular Sales
Detroit, Michigan

Tubular Service Corp.
Springdale, Pennsylvania

Ward Steel Co.
Boston, Massachusetts

Ward Steel Service Company
Dayton, Ohio

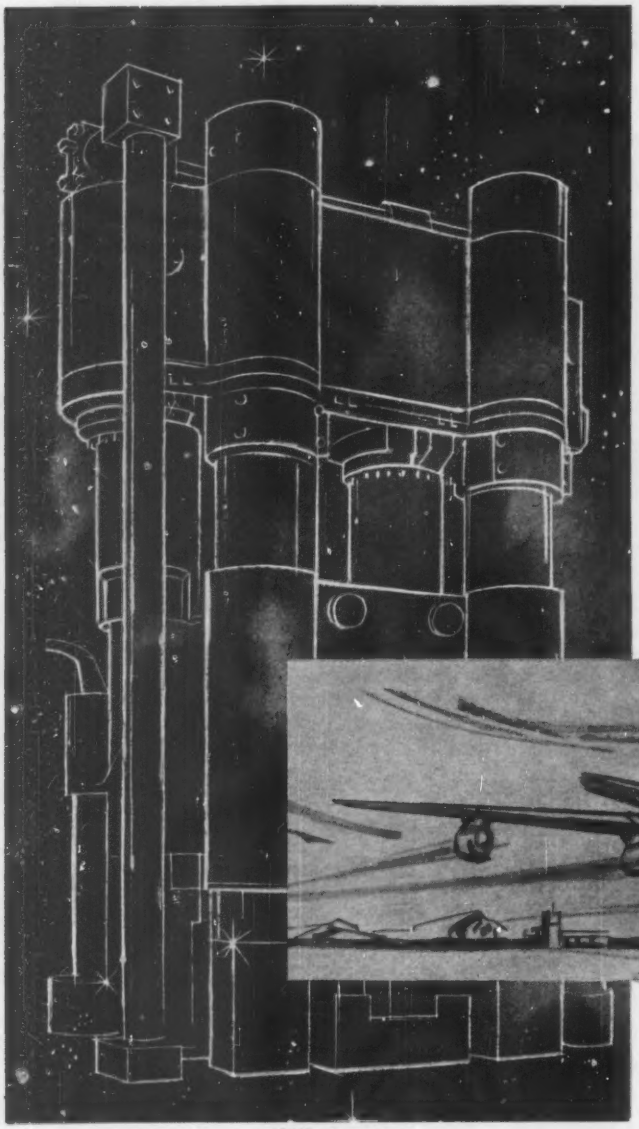
Pittsburgh Steel Company

Grant Building • Pittsburgh 30, Pa.

DISTRICT SALES OFFICES

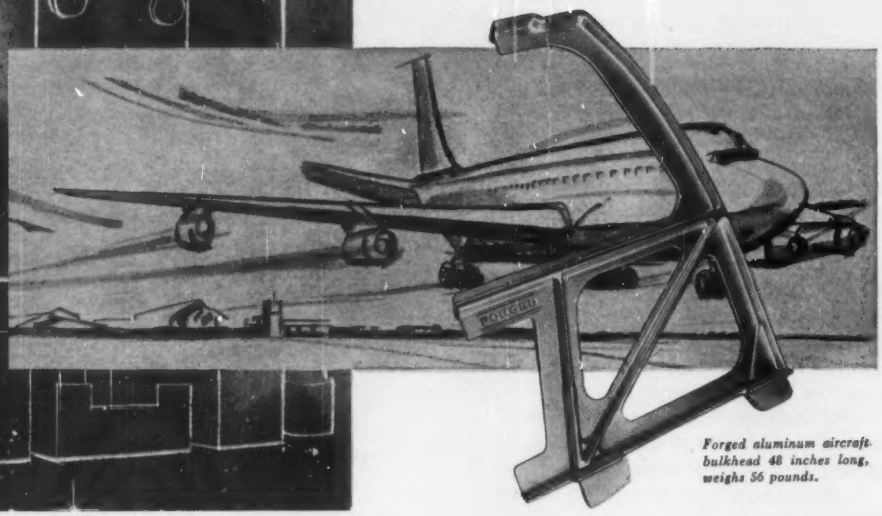
Atlanta, Chicago, Cleveland, Dayton, Detroit, Houston, Los Angeles, New York, Philadelphia, Pittsburgh, Tulsa, Warren, Ohio

Circle 481 on Page 19



Modern hydraulic forging press exerts 35,000 tons pressure.

HOW FORGED PARTS help airplanes haul bigger payloads



Forged aluminum aircraft bulkhead 48 inches long, weighs 56 pounds.

In an airliner, every pound of weight saved is worth hundreds of dollars ... in revenue-making payload. And in military aircraft, pounds saved mean added miles-per-hour ... or added load carried.

In commercial products ... trucks, cars, materials-handling equipment ... the pounds of dead weight you eliminate by using forgings make money year-after-year for the operator. The forging process lets you put the metal exactly where you need it to carry the load, withstand shock or vibration, endure torsion. And with not a surplus ounce of non-working weight going along just for the ride.

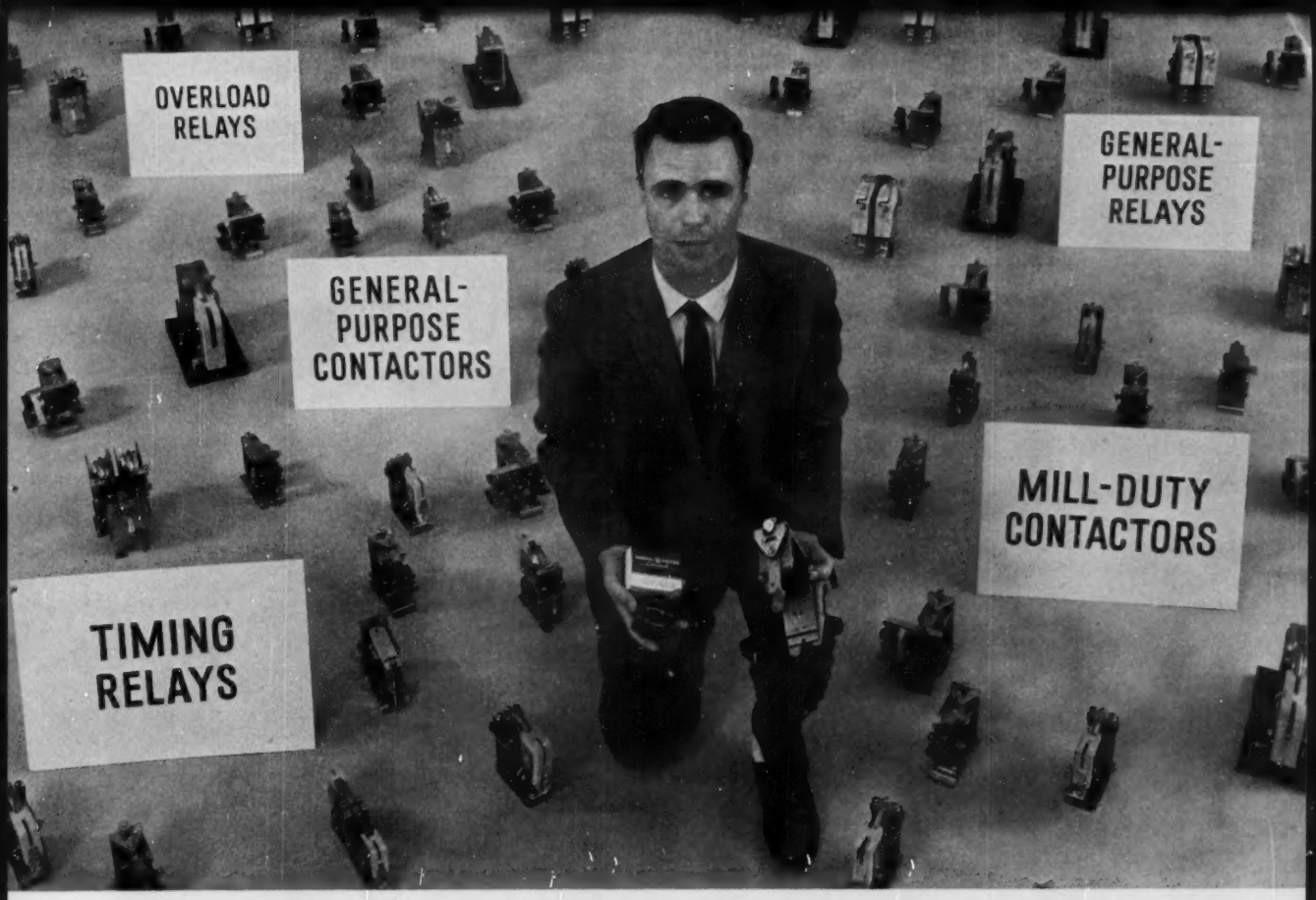
Forged parts are the designer's friend ... strong where strength is needed, lowest in weight, twice-worked by original rolling of the best metals *plus* the hammer blows or high pressures of the forging process.

Write for literature to help you specify, design, and procure forged parts.

When it's a vital part, design it to be FORGED

Drop Forging Association • Cleveland 13, Ohio

Names of sponsoring companies on request to this magazine



GENERAL ELECTRIC DC CONTACTORS AND RELAYS

Over 100 devices – available when you need them

Now . . . you don't need to wait for delivery of a particular contactor or relay . . . or to carry a large inventory . . . just to be sure you have the correct device for a job. With General Electric's new d-c contactors and relays—featuring "building-block" design—you assemble the device you want . . . when you ***need*** it . . . from standard components right in your own plant. More than a hundred different devices can be assembled from a parts stock of as few as a dozen General Electric "building-block" components!

This amazing versatility means ***immediate availability*** of any General Electric device. A "universal" contact block is the building unit for all types of contactors and relays. Choice of the frame-and-coil assembly and standard assembly kit permits variation in devices to meet your specific application.

Three types of contactors and six types of relays—for general purpose, mill-duty, overload and timing applications—can be assembled using this unique, cost-saving approach.

NEED OTHER COMPONENTS?

General Electric also has complete lines of plate rheostats and resistors for all your control needs. For more information, contact your General Electric Sales Representative or mail this coupon today! *Industry Control Department, Salem, Virginia.*

GENERAL ELECTRIC

Resistors—vitreous-enameled and wire- and ribbon-wound types from 5 to 1210 watts. Fixed, slide-wire, or tapped types available.

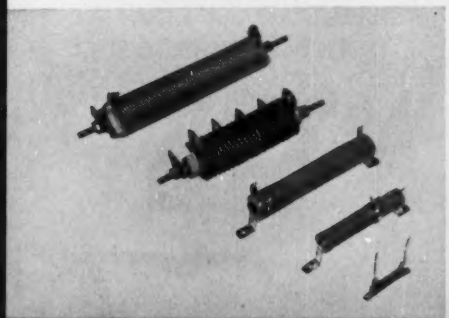
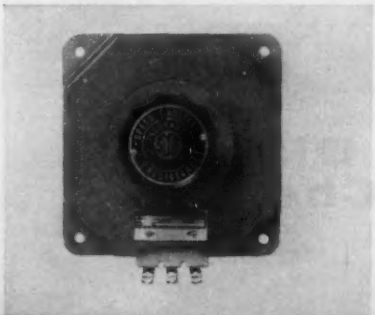


Plate-type rheostats—windings are completely encased in metal to give longer and more reliable service for any application.



To: Section F784-26
General Electric Co.
Schenectady 5, N. Y.

Please send the following bulletins:

- ☐ GEA-6621—D-c contactors and relays
- ☐ GEA-6592—Resistors
- ☐ GEA-6474—Plate-type field rheostats

Name_____

Company_____

Address_____

City_____

State_____

Circle 483 on Page 19

BUSTLE-BOUND or FAST 'N' SMOOTH

how does your chrome plating stack up?

You can keep your chrome-plating process in step with today — with Diamond CPA 1800®.

For example: Viking Copper Tube Co., of Cleveland, Ohio — with mandrels plated by the CPA 1800 process — draws 1500 feet of copper tubing per minute to extremely close tolerances with almost unbelievably reduced deterioration in machine tools!

This same job-proven additive is available to you. To increase plating speed and covering power. To allow a broader operating range. To simplify anoding and produce a brighter, harder coating. To improve the metallurgical characteristics of chromium plate.

In short: Diamond CPA 1800 can cut your unit costs and save you money. Diamond developed it. Your Diamond CPA 1800 Distributor can supply it where and when you need it.

For further information write or call Diamond Alkali Company, 300 Union Commerce Building, Cleveland 14, Ohio.

Diamond Chemicals

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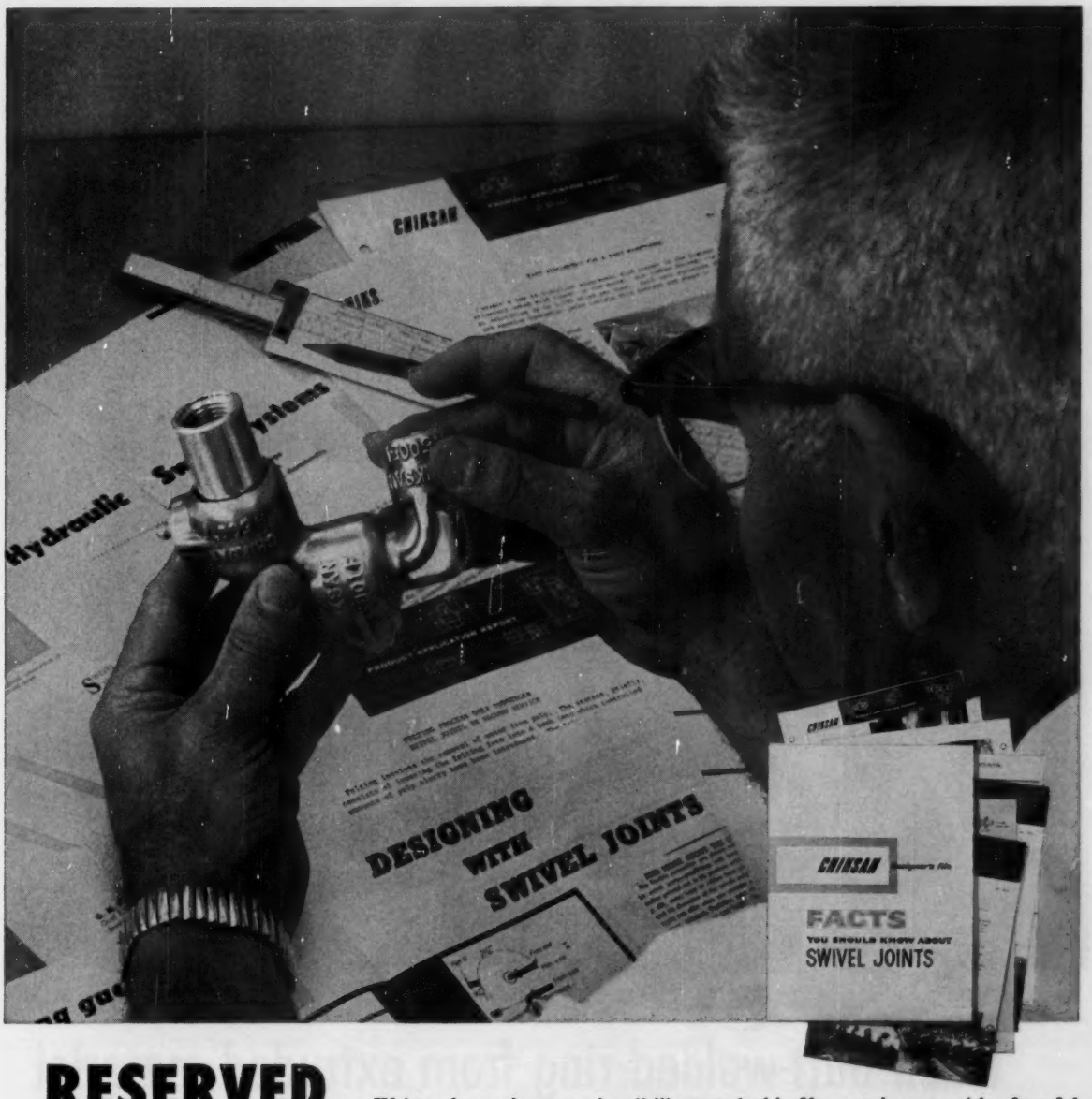

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FOR THE ENGINEER CONCERNED WITH DESIGNING SAFE, DURABLE, FLEXIBLE LINES

Send for your copy of
"FACTS YOU SHOULD KNOW ABOUT SWIVEL JOINTS"

CHIKSAN

Written by engineers and well illustrated, this file contains a wealth of useful information on the application of swivel joints in line design. You'll find facts and figures on torque, geometric characteristics, thrust and radial loads. There's information on how to approach design problems and a quick comparison between swivel joints and other flexible devices. And, you'll find a group of actual installation reports with diagramatic drawings showing how the swivel joints were applied in the system. Be sure you have a copy of "Facts you should know about Swivel Joints" in your possession. Write Chiksan for your file today.

CHIKSAN COMPANY, 300 North Brea Blvd., Brea, California
Please send me a copy of "Facts you should know about Swivel Joints."

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#60-53

fmc
A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

CHIKSAN COMPANY—Brea, California • Chicago 5, Ill. • Newark 2, N. J. • Divisions: Chiksan International, Hamer Valves, Weco • Subsidiary: Chiksan of Canada Ltd.

Flash butt-welded ring from extruded material slashes away 64 lbs. of stainless 310

Only 1/3 as much material was required when a special extruded section was substituted for bulky bar stock in this flash butt-welded ring. By leaving 2/3 of the material at the mill, instead of hogging it out, Amweld saved its customer $76.83 per ring—plus hours of expensive machining. (Savings compared to the forgings originally used are even greater.)

Amweld is equipped to supply flash butt-welded rings and circular products in stainless, titanium, aluminum, as well as a wide variety of corrosion-resistant alloys. If you would like to know more about Amweld's welding, fabricating and complete machining facilities, phone or write.

GET THE FACTS ABOUT AMWELD

New 20-page catalog describes flash butt-welded rings and circular products manufactured by Amweld. Also booklet entitled, "How Flash Butt-Welded Rings are Made."

AMWELD® INDUSTRIAL PRODUCTS

THE AMERICAN WELDING & MFG. CO. • 130 DIETZ ROAD • WARREN, OHIO

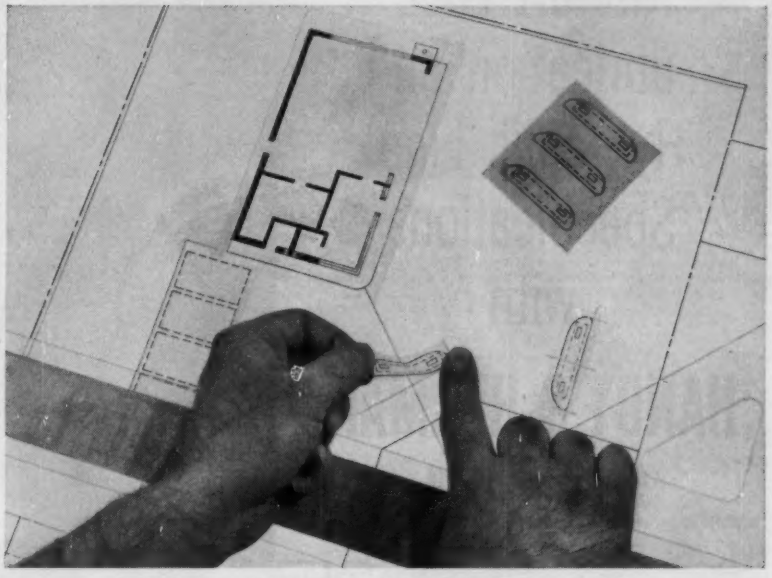
Circle 486 on Page 19

Low Cost Insurance Program Protects Original Drawings From Loss or Damage

Have you ever thought what would happen if your company's original drawings were lost or damaged? How much trouble and expense would be involved to replace them? Many companies are adopting a simple "insurance" program to meet just such a problem . . . a program which requires neither expensive new equipment or radical adjustments of established procedures. The program consists of two parts. First, recognizing the cost of *any* drafting medium is always an infinitesimal part of the investment in a finished drawing, the companies standardize on the drafting medium which affords their original drawings maximum life. Second, they institute the policy that original drawings must be used only as *masters*, that all printmaking must be done from *duplicate originals* of the masters.

The perfect answers to both these needs are Dietzgen polyester *drafting* film for all original drawings, and Dietzgen *diazo-sensitized* polyester film for duplicate originals! Dietzgen's polyester film is so tough it cannot be torn. Its crystal-clear transparency is permanent . . . never fogs or yellows. It's dimensionally stable; insensitive to temperature, humidity, acids or alkalines. The drawing surface of Dietzgen's polyester drafting film is unexcelled . . . accepts pencil or ink perfectly; erasures are smudge-proof and ghost-free. Inexpensive duplicate originals are quickly produced *in any desired quantity* by contact printing the original drawing on Dietzgen's diazo-sensitized polyester film. The images developed are *exact* duplicates of the original . . . uniform and permanent to provide the finest reproducibles attainable.

NEW PRINTED-ELEMENT DRAFTING TECHNIQUE CUTS DESIGN COSTS 66%



Printed-element drafting ends tedious redrawing of repeated elements . . . produces accurate reproducibles in record time.

The regional engineering office for a large oil company employed 15 draftsmen to prepare construction plans for new filling stations. Investigation of their drafting procedures revealed the majority of "board-time" was consumed redrawing, in varied combinations, the basic elements such as pump islands, hoists, and rest rooms, used in each station. Redrawing of the repeated station elements was tedious work and wasted valuable man-hours. Dietzgen solved this problem by recommending a new *printed-element* drafting technique utilizing Dietzgen's diazo-sensitized, adhesive-backed polyester drafting film. Duplicate originals of all repeated station elements are now printed on the Dietzgen film medium. The draftsman simply selects the proper elements for each station, mounts them on a sheet of Dietzgen polyester drafting film, and the plan is 75% complete without drawing a line! The finished drawing is a high-transparency reproducible, ready to produce any number of prints.

Today, five draftsmen handle the entire work load. The cost of station design has not only been slashed 66%, but the other ten draftsmen have brought the department's backlog down to a desirable level. Service to other departments has been greatly improved too; and rush jobs are handled on a basis never before possible.

Printed circuits and plant layouts are other design activities where Dietzgen's *printed-element* drafting has been used with amazing cost-cutting, time-saving success.

Drafting-Printmaking Booklet reports new techniques for solving engineering and production problems

This new 36 page booklet describes a wide variety of engineering and production problems that have been solved with advance techniques in drafting and printmaking pioneered by Dietzgen. The concise, problem-solution approach suggests ways in which you may improve the efficiency within your engineering department or eliminate production bottlenecks. Write today on your company letterhead for the Mechanics of Modern Miracles. Ask for Publication SPD2-M-160. Eugene Dietzgen Co., Chicago 14, Illinois

DIETZGEN

EVERYTHING FOR DRAFTING SURVEYING & PRINTMAKING

Titeflex, Inc., Meets Aircraft Fuel, Lubrication and Hydraulic Line Specifications with

HANDY & HARMAN BRAZE 541

Titeflex operator brazes assembly with torch and hand-fed Handy & Harman Alloy BRAZE 541. *Titeflex is unique in that it makes flexible hose assemblies from raw material to end product—"From End to End, Inside and Out, made RIGHT In Our Own Plant."*

This Springfield, Massachusetts, manufacturer of aircraft and missile fuel, lubrication and hydraulic lines finds that silver alloy brazing with Handy & Harman BRAZE 541 meets rigid operating requirements "all the way down the line."

The tubing and fittings of many of the wide range of assemblies made by Titeflex are 321, 316 and 347 stainless steel and Monel. Brazing is a hand torch, wire and HANDY FLUX operation.

BRAZE 541 is a plastic alloy which melts at 1325° F and flows at 1575° F. Its strength—in shear—at elevated temperatures is 21,500 psi at 500° F and 15,000 psi at 750° F. This alloy's ductility in resisting stress and vibration is very high and its resistance to oxidation and corrosion is equally impressive. The composition of BRAZE 541 is 54% silver, 40% copper, 5% zinc and 1% nickel. It meets AMS Specification 4772.

Aircraft and missile component manufacturers and fabricators are finding—to their and their products' benefit—that Handy & Harman silver alloy brazing is the full and *final* solution to their metal-joining problems. BRAZE 541 is but one of a large family of Handy & Harman alloys, for both low and high temperature applications. We would like to more fully acquaint you with BRAZE 541 and with the advantages that come naturally to silver brazing as a metal-joining (both ferrous and nonferrous) method. Handy & Harman, 82 Fulton Street, New York 38, N. Y.

FOR A GOOD START: BULLETIN 20

This informative booklet gives a good picture of silver brazing and its benefits... includes details on alloys, heating methods, joint design and production techniques. Write for your copy.

Your No. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN

General Offices: 82 Fulton St., New York 38, N. Y.

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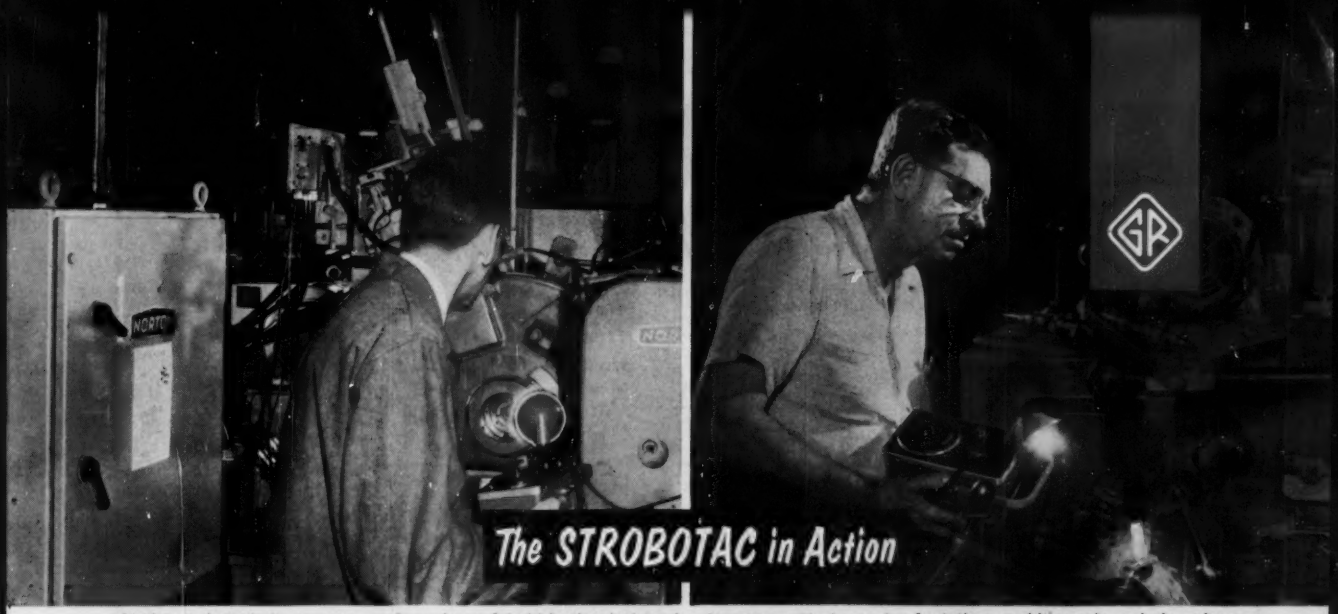

Stroboscopic techniques are an extremely useful aid in the design of machine tool components such as this Automatic Grinding-Wheel Balancer manufactured by Norton Company. This device reduces wheel balancing time to 5 seconds, and eliminates vibration that might cause chatter. The new Strobotac, with its "long-throw" beam of intense white light and extremely short flash duration, shows up nearly hidden mechanical details of the Balancer's operation.

Checking critical speeds of rotating machine parts and observing performance under actual operating conditions are two jobs readily handled by the Strobotac. At Norton Company, the Strobotac checks operation of an automatic cam-shaft grinder. In order to obtain the best possible finish on the cam surface it is desirable to grind at high speeds, yet for safety reasons the wheel should not be operated above rated speed. The Strobotac's flashing rate stability and 1% accuracy make it possible to hold circumferential velocity of the ALUNDUM vitrified wheel to an exact pre-established point below rated speed.

STROBOTAC

for the Design of Better Machine Tools

Consider the new Strobotac and its benefits as an aid in the design, test, and quality control of your product. This unique instrument lets you observe cycling machine parts and functions as though stopped or in slow motion while the apparatus is running at normal speed. Strobotac's concentrated beam of high intensity white light, probes into the heart of complex machinery. The instrument's extremely short-duration flash virtually eliminates blur and shows up details of mechanical motion formerly impossible to see.

For speed measurement, the Strobotac serves as an accurate tachometer. It is preferable to other speed measuring devices because no contact with the machine is necessary and no power is absorbed.

Write for more information or, better yet, contact one of our district sales engineering offices and ask for an on-the-job trial of the new Strobotac.

TYPE 1531-A STROBOTAC®
Electronic Tachometer and Motion Analyzer.
. . . **$260.**

Flashing-Rate Range: 110 to 25,000 flashes per minute direct-reading; useful for speed measurements to 250,000 rpm.

Accuracy: ±1% of dial reading — permanently assured by neon-bulb calibrator on instrument panel.

Flash Duration: 0.8, 1.2, and 3.0 millionths of a second for high-, medium- and low-speed ranges, respectively.

Peak Light Intensity: 0.21, 1.2, and 4.2 million beam-candlepower (minimum) on high-, medium- and low-speed ranges, respectively.

External Triggering: May be triggered with a mechanical contactor on 6-volt peak-to-peak signal.

Power Supply Requirements: 105-125 (or 210-250) volts, 50-60 cycles or 400 cycles.

Mounting: "Flip-tilt" case serves as adjustable stand and handy carrying case.

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Circle 489 on Page 19

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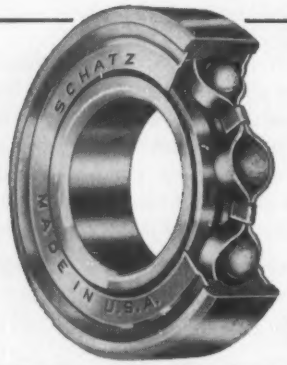

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GEAR-O-MATIC® performs all functions typically required in radio-controlled or manual-switch garage door operation ... functions applicable to operation of many other products ... perhaps yours.

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Integrated with the Franklin Electric Motor is a control box with 24 volt A. C. circuitry. System includes plug-in connection for radio or automation control and receptacle for light bulb or power extension line. All limit and safety reversing switch settings are adjustable.

From the Home of DEPENDABLE Electric Motors

For more data write for "FACTS ABOUT FRANKLIN GEAR-O-MATIC®"

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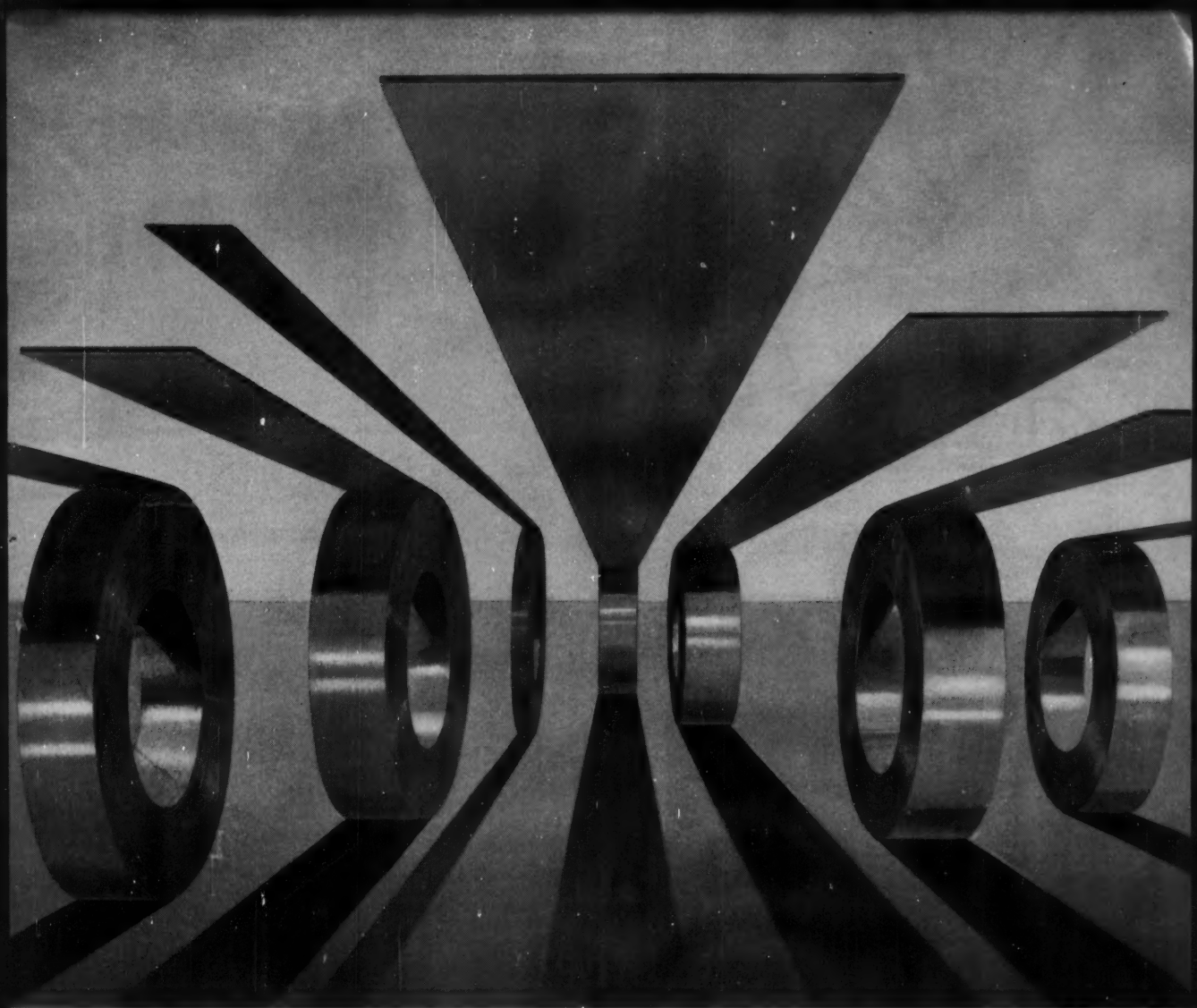
Circle 492 on Page 19



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Circle 493 on Page 19

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1 to 20 H.P.—900 to 3600 R.P.M.—with straight or tapered shafts

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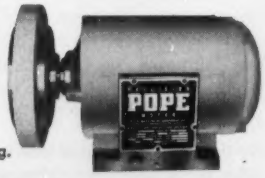
Ask for data sheet SK-306 for outline dimensions and specifications.

Let us quote you on these Precision Driving Motors for use on all your equipment where a real Precision Motor is required.



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- What a solvent cement can do
- Something new in electrical insulation
- A bulletin on plastics

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A good adhesive does a lot more than stick two things together. You can use

today's solvent-type adhesives to:

- smooth out surface contours (as in brake linings and in jet aircraft skins, where adhesives can eliminate the need for projecting rivets);
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One super-sticker in this class sets with only contact pressure and at room temperature; adheres very well to metal, wood, phenolic laminates, glass, and rubber. Block shear tests show 4500 psi at room temperature, and tensile strength is 10,000 psi. The cement has excellent resistance to all ordinary solvents, water, oils, alkalies, and acids; has high capillary attraction and does not shrink.

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This insulation idea solves three engineering problems at once in a dry-type transformer. You'd find the same approach helpful in a circuit breaker, a panel, or other heavy-duty electrical gear.

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1. Greater mechanical strength. This ends cracking or breaking of insulation when windings are forced into position.
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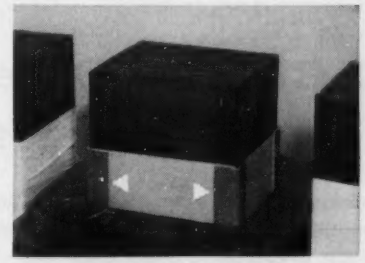
3. Higher heat resistance. The angle is made with glass-reinforced Hetron,® our inherently heat-resistant polyester resin. It meets NEMA GPO-1 specifications, and has UL-recognized flame retardance. It is designed for equipment operating at Class B temperatures (266° F.).

Now for the clincher. You can get flame-retardant structural insulation like this *from stock*—in a wide range of cross-section shapes including channels, in widths up to $9\frac{21}{32}$ inches, lengths to 76 inches.

You get them not from us but from the manufacturer, The Glastic Corporation, 4321 Glenridge Road, Cleveland 21, Ohio. The Glastic people will be glad to send you details on stock channels and angles if you write to them.



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What if he hasn't got Sweet's File handy? He sends us the coupon below, requesting Durez *Bulletin D400*. The same fact-filled eight pages come to him posthaste.

For more information on Durez materials mentioned above, check here:

- ☐ Phenolic resins (12-page bulletin listing applications)
- ☐ Hetron fire-retardant polyester resins (data file, including names of fabricators)
- ☐ Durez plastics *(Bulletin D400)*

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Circle 495 on Page 19

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Savings and improvements like these can be made in your product with SPEED NUT Brand Fasteners. If you'd like to have a Tinnerman FASTENING ANALYSIS made to help you find such savings possibilities, call in your SPEED NUT representative. The service is free... you'll find him listed in the Yellow Pages and in SWEET'S PD File under "FASTENERS." Or write direct.

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MACHINE DESIGN
December 8, 1960

Bridging the Gap

IS four years long enough to educate an engineer? Some educators have answered the question with a flat "no." The five-year curriculum already is standard at more than one engineering college.

Others are asking the opposite question: Is four years too long to wait for an engineer to start contributing his sorely needed services to industry—and to start earning his living? That is being answered in at least one leading engineering college, where year-round operation is replacing the traditional nine-month academic year. This plan permits completion of four years' work in three.

Whatever the mechanism of curriculum juggling, the rapidly expanding field of engineering is placing unprecedented pressure on the college curriculum. At the same time, recognition of the need to develop "well rounded" engineers has created a demand for more humanities-type courses. Something must yield, and currently the practical and hardware courses are being given the heave-ho.

Of immediate concern in our field is the traditional "design of machine elements" type of course, currently undergoing a major revolution. Replacing the practical, more or less empirical, approach are various attempts to present fundamental concepts along with more emphasis on the theoretical and scientific viewpoints. With this we have no quarrel. The change is long overdue.

But it means that industry, which has long deplored the lack of practical background in newly recruited graduates, will find that situation aggravated in the future.

The answer is plain. Industry will find it necessary, more than ever, to accept the responsibility of helping green graduates to become seasoned engineers.

In-plant training programs make it possible for individual companies to supplement .their engineers' basic education with specific courses tailored to their own needs. Murdick and Smallwood, elsewhere in this issue, tell how.

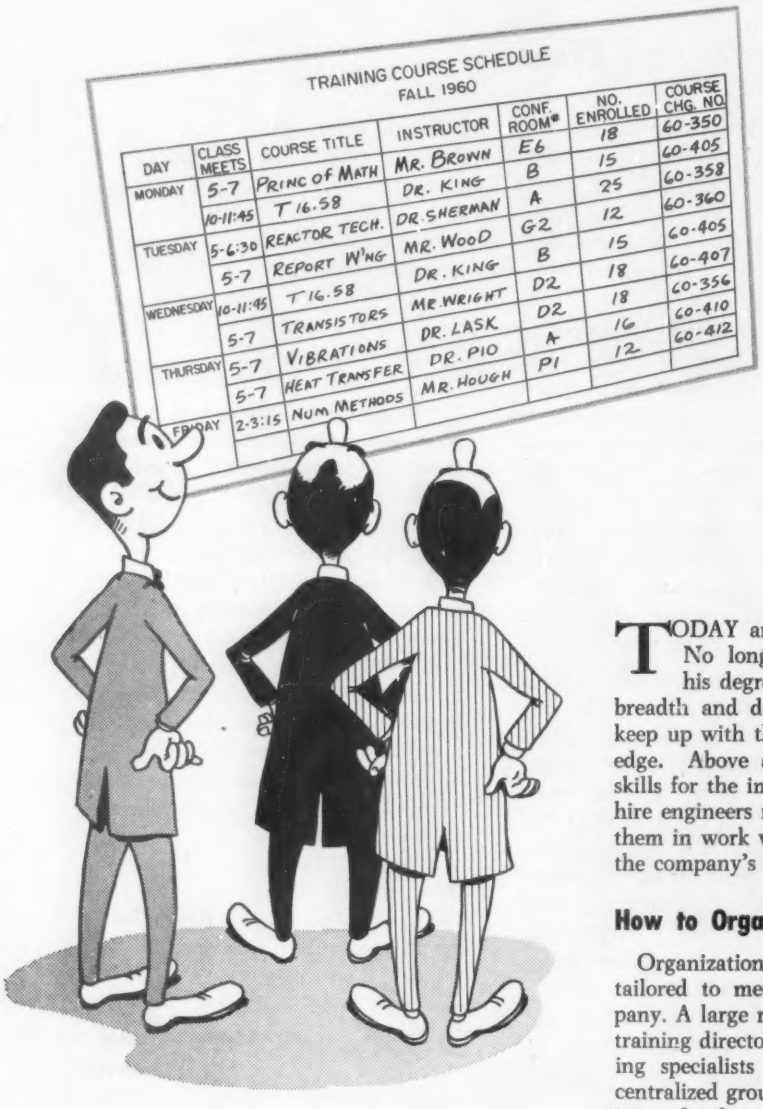
Whatever the cost of bridging this gap, the faster maturing of young engineers should return big dividends on the investment.

Colin Carmichael

EDITOR

Basic education for an engineering degree needs bolstering through company training programs. College graduates with a firm grasp of fundamentals need job-related specific knowledge. Men moving up the promotion ladder need leadership and communication skills. To meet these needs, here is a guide for . . .

Training Engineers


TRAINING COURSE SCHEDULE
FALL 1960
DAY | CLASS MEETS | COURSE TITLE | INSTRUCTOR | CONF. ROOM* | NO. ENROLLED | COURSE CHG. NO.
MONDAY | 5-7 | PRINC OF MATH | MR. BROWN | E6 | 18 | 60-350
10-11:45 | T 16.58 | DR. KING | B | 15 | 60-405
TUESDAY | 5-6:30 | REACTOR TECH. | DR. SHERMAN | A | 25 | 60-358
5-7 | REPORT W'NG | MR. WOOD | G2 | 12 | 60-360
WEDNESDAY | 10-11:45 | T 16.58 | DR. KING | B | 15 | 60-405
5-7 | TRANSISTORS | MR. WRIGHT | D2 | 18 | 60-407
THURSDAY | 5-7 | VIBRATIONS | DR. LASK | D2 | 18 | 60-356
5-7 | HEAT TRANSFER | DR. PIO | A | 16 | 60-410
FRIDAY | 2-3:15 | NUM METHODS | MR. HOUGH | P1 | 12 | 60-412

TODAY an engineer needs on-the-job training. No longer is school over when he obtains his degree. He needs to develop professional breadth and depth in his field. He also needs to keep up with the rapidly moving frontiers of knowledge. Above all he needs to acquire new, special skills for the immediate job. Companies now tend to hire engineers regardless of their specialty, and train them in work which satisfies their own interests and the company's needs.

How to Organize for Training

Organization of the training function must be tailored to meet the needs of the particular company. A large multiplant company requires a central training director or technical service, as well as training specialists in each plant or laboratory. The centralized group is required to establish over-all policies, develop company-wide courses, and provide co-ordination and interchange of information among the plant training directors. The plant training di-

R. G. MURDICK
Engineer—Technical Information Group

G. L. SMALLWOOD
Specialist—Training Courses

Knolls Atomic Power Laboratory
General Electric Co.
Schenectady, N. Y.

on the Job

How to Administer the Training Program

Suppose that the education and training program has been planned as a mixture of company courses, tuition refund offerings, and external technical meetings and seminars. How is such a program administered? The first problem is to find a balance between the applicants for all courses and the amount of money the company is willing to budget. With this as a starter, a list of the steps to be taken can be made:

1. **Survey the interests of the engineers in proposed courses.**
2. **Ask the managers who they recommend to take each course.**
3. **Forecast enrollment in the various courses. (After the program has been in effect two or three years, historical data may be used to forecast enrollment rather than the results of the time-consuming surveys). Compare with budgeted allowance.**
4. **Line up instructors on a tentative or standby basis.**
5. **Establish a procedure for enrollment application.**
6. **Prepare a brochure of courses including descriptions, enrollment conditions, and charge, Fig. 3.**
7. **Send copies of the brochure to all departments or sections about one month before registration starts. Use company communication channels to make everyone aware of the brochure of courses, the closing dates for applications, and the procedure for applying. It is important not to send out the brochures too early, lest they be forgotten or lost or too late for the men to have an opportunity to discuss their plans with their managers.**
8. **When all applications are in, set up the courses and the engineers to be accepted on the basis of managers' priorities, engineers' preferences, and available instructors, facilities, and funds.**
9. **Establish the time and location of classes. A chart is helpful in keeping track of the educational courses.**
10. **Notify managers which engineers were accepted for courses —and which were not accepted, with a few words of explanation. Give the starting date, time and place of each class.**
11. **Notify each instructor of time and location of his class. Make sure instructors have all materials, handouts, and visual aids which they require.**
12. **Spot-check by auditing classes occasionally to get a feeling for how the instructors are doing.**
13. **At the end of the course obtain the students' evaluation of the course and of the instructor.**
14. **Obtain instructors' comments and discuss with each instructor the comments of his class.**
15. **Notify the managers of successful completion of courses by their engineers, place a copy in the engineers' personnel folder, and send certificate to manager for presentation to engineer.**

rector develops the curriculum and training method needed by his plant, Fig. 1.

In the smaller company, the training director may report to the engineering manager, the employee relations manager, or even to the production manager when there is a strong industrial engineering function.

How to Set up the Training Program

Elements of the Program: A main duty of the training director is to analyze both the needs of the company and the resources available to prepare a suitable program. The broad program of training engineering personnel may be made up of any combination of the following elements:

1. Integrated company technical programs
2. Individual company technical courses
3. Company managerial courses
4. Nontechnical courses
5. Short, full-time company seminars or courses
6. Seminars, work shops, or courses sponsored by groups outside the company
7. College tuition refund courses and advanced degree programs
8. On-the-job training programs

Table 1—Training Objectives

Based on . . .
1. Analysis of the effectiveness of the engineering organization.
2. Analysis of individual engineers' performance, problems, and potential.
3. Analysis of engineering management.

As Discovered By . . .
1. Observing—Employees, their work, work flow, communications, relationships.
2. Asking—Engineers, supervising engineers, management, staff people.
3. Analyzing—Organization, engineering policies, engineering programs, schedules and costs, engineering position descriptions.

To Determine . . .
1. What is the problem that engineering training could alleviate?
2. What is our present technical strength?
3. How do we go about correcting the problem?
4. What order of priority do we want to place on fulfilling our technical training needs?

The integrated technical program is found usually in the medium-size and large companies. General Electric's three-year Advanced Engineering Program is perhaps one of the best known throughout industry.

Nontechnical courses are those such as conference leadership, human relations, reading improvement, report writing, and business management.

The widespread use of workshops, symposiums and seminars has grown with the urgent need for more communication both within and between the rapidly advancing sciences and technologies. This type of training permits face-to-face exchange of problems—question-and-answer sessions—and may or may not use experts to provide answers. They are intensive and usually well-organized sessions.

In college tuition refund courses and programs leading to advanced degrees, the company refunds tuition or some fraction of tuition to the employee upon successful completion of each course. These programs are growing in popularity. The smaller company may not find it economical to set up a variety of company courses on a continuing basis. Some engineers feel a sense of accomplishment in working toward an advanced degree rather than taking a number of company courses, however well-designed they may be to meet their immediate needs.

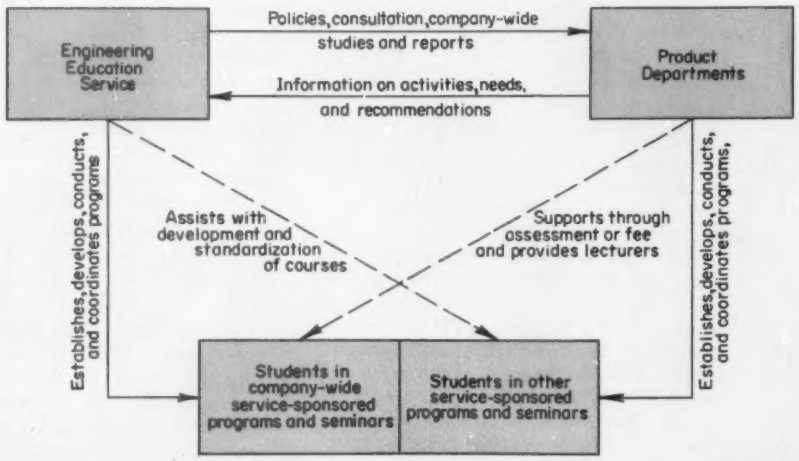

Engineering Education Service
Policies, consultation, company-wide studies and reports
Information on activities, needs, and recommendations
Product Departments
Establishes, develops, conducts, and coordinates programs
Assists with development and standardization of courses
Supports through assessment or fee and provides lecturers
Establishes, develops, conducts, and coordinates programs
Students in company-wide service-sponsored programs and seminars
Students in other service-sponsored programs and seminars

Fig. 1—Functional relationships in technical training.

Determining the Needs: Although the company pays, the training director must satisfy two customers—the company and the engineer. A training program will not be successful if the engineers do not enroll in the program or if they must be drafted into courses unwillingly. Therefore, after he has determined management's views on what skills need to be developed, the training director should survey the feelings of engineers. Since the training program must meet short, intermediate, and long-range requirements, reactions from management and engineers should be sought in this frame of reference.

Needs for technical training are better investigated by personal interview with the managers and engineers than by survey letters. An appointment letter, Fig. 2, may prepare the way for the interview. Considerable explanation and probing by the training director are often needed to help managers crystallize their thinking. Table 1 may be helpful in setting objectives.

In determining the needs for specific training courses or programs, the training director and management must take into account and evaluate the following:

1. Size and organization of the company and the engineering function.
2. Type of research, development, or design being conducted.
3. Short-range (1 to 2 years), intermediate-range (3 to 5 years), or long-range company objectives for developing men.
4. Interest and enthusiasm (or lack) among engineers for various types and areas of training.

Evaluating Alternative Programs: Cost is a major factor in the selection of a suitable training program. If a nearby university gives adequate and needed courses, the training director must usually first weigh the advantage of company-sponsored courses against those of a tuition-refund program. The seminars and workshops serve a purpose different from either of these and may be combined to supplement either one.

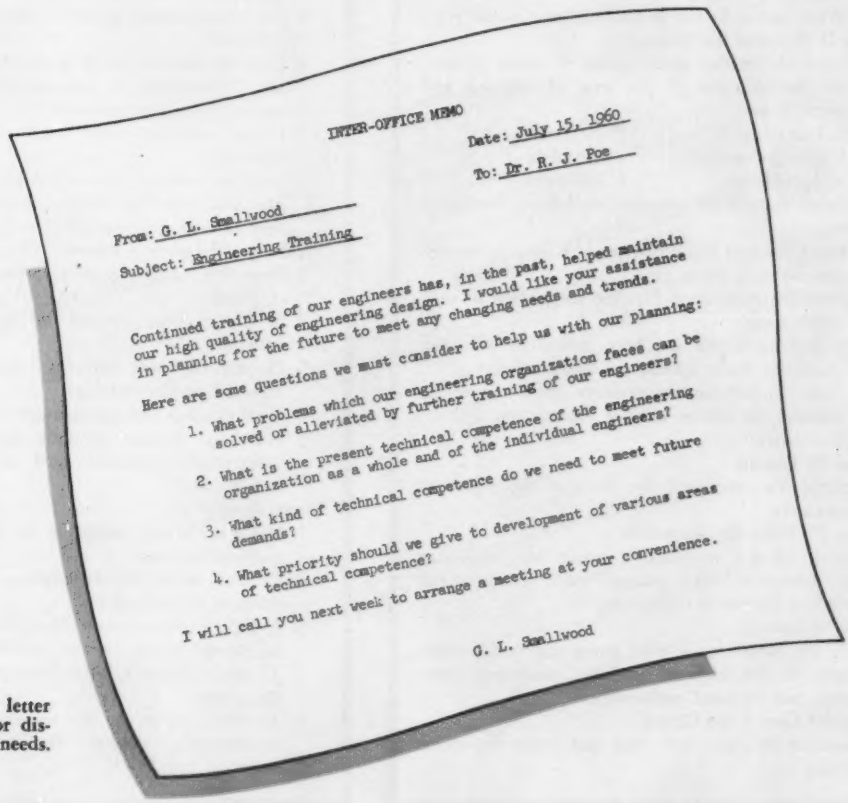
Comparison of Company-Sponsored and Tuition-Refund Programs

Company-sponsored programs can:

- be tailored exactly to company needs.
- be given at any time of day or evening.
- cost less.
- promote technical interchange among students.
- be taught conveniently in the company plant.

On the other hand tuition-refund programs can:

- lead to an advanced degree through accredited courses.



INTER-OFFICE MEMO

Date: July 15, 1960

To: Dr. R. J. Poe

From: G. L. Smallwood

Subject: Engineering Training

Continued training of our engineers has, in the past, helped maintain our high quality of engineering design. I would like your assistance in planning for the future to meet any changing needs and trends.

Here are some questions we must consider to help us with our planning:

1. What problems which our engineering organization faces can be solved or alleviated by further training of our engineers?
2. What is the present technical competence of the engineering organization as a whole and of the individual engineers?
3. What kind of technical competence do we need to meet future demands?
4. What priority should we give to development of various areas of technical competence?

I will call you next week to arrange a meeting at your convenience.

G. L. Smallwood

Fig. 2 — Typical letter setting the stage for discussion of training needs.

- stress fundamentals rather than company-centered specifics.
- furnish fully qualified instructors.
- furnish adequate facilities—classrooms, laboratories, and equipment.
- stimulate cross-fertilization of ideas with engineers from other companies.

How to Develop a Company Course: To develop a single good company course on some subject over a five-year period is not difficult, but to do so in two years requires a knowledge of educational techniques and pitfalls. Neither the course nor the training director may survive a five-year incubation period, management being oriented to look for immediate results. Table 2 shows a step-by-step procedure for making the company course operate successfully within two years.

Nontechnical Courses that Benefit Engineer and Company: Nontechnical courses help the individual make effective use of his technical ability in his environment.

The training director must work with managers to make sure that such courses are taken at the proper time in each engineer's career. For example, early in his career, conference leadership or public speaking might be of primary value. Later, as he gains in both technical competence and skill in relating himself to his environment, courses in Business Management or Supervisor's Training would be of value in preparing him to lead younger engineers in achieving organization objectives.

Table 2—Training Course Countdown

Phase I Plan for the Course
1. Where will the money come from?
2. Who will be the trainees?
3. Who will select the trainees?
4. Who will be the instructors?
5. What should be the emphasis of the course?

Phase II Blueprint the Course
1. Establish detailed specifications of course content.
2. Set the objective of the level of teaching and learning as:
   a. Knowledge
   b. Comprehension
   c. Application
   d. Analysis
   e. Synthesis
   f. Evaluation
3. Select method of presentation—lecture, workshop, etc.
4. Select the best qualified person to develop the lessons for each major topic.
5. Establish completion date for preparation of each major topic.
6. When the course has been completely prepared, check the drafts against the specifications.
7. Have an independent reviewer check the course material for clarity, level of explanation, and cohesiveness.

Phase III Rewrite
Rewrite the course on the basis of the reviewer's suggestions.

Phase IV Train the Instructors
Run a 1-2 day workshop to orient and familiarize the instructors with general teaching techniques including the use of visual aids.

Phase V Test
Run the course for a pilot group and evaluate the course on the basis of auditing, instructors' comments, and students' evaluation.

Phase VI Launch the Course
Continue followup each year and revise the course if need be.

Table 3—Standards of Program Evaluation

Scope of Training Program
1. Degree of need for program.
2. Degree to which short and long-range goals are planned for.
3. Are any major needs not being met? Is anything being done about it?
4. Is program being continuously reviewed and revised?

Administration of the Training Program
1. Is the training function clearly defined, and is responsibility properly assigned within the organization?
2. Are the proper kinds and numbers of people assigned to the training function?
3. Are there adequate facilities, space, equipment, and materials?
4. Does the training group receive periodicals, books, and information to maintain contact with advances in industry training?
5. Is the training being done on time and as planned?
6. Does the training director publicize training activities and make his services understood by management and engineers alike?

Teaching and Learning Process
1. Does the course actually present the material outlined?
2. Is the material covered in proper depth and breadth?
3. Do the engineers participate actively in discussion and problem solving?
4. How effective is the instructor?
5. Were the students properly selected relative to background, knowledge, need for course, ability, and interest?

Direct Results
1. Did the training succeed at the intended level of teaching-learning?
2. To what extent did the engineers learn what was intended to be taught?
3. Are the engineers more effective in problem-solving on the job in the area covered by the course?
4. To what degree are the engineers satisfied with the course?
5. To what degree are the managers satisfied with the immediate results? The results over a long period of time?

Table 4—Three Methods of Course Evaluation

1. Informal evaluation
   Inferences drawn from comments by trainees.
   Do trainees recommend the course? Is the course oversubscribed?
2. Systematic evaluation
   This method covers most formal attempts to collect information such as
   a. Beginning and ending test scores
   b. Performance ratings
   c. Observation of post-training work by the trainee
   d. Analysis of production, cost, turnover, and employee attitude reports
   e. Formal evaluation of the course by the trainee
3. Experimental evaluation
   Predesigned experiments with control groups which are subject to statistical analysis of variances.

Measurement

Measurement of the profitability of inplant training of engineers in dollars poses a difficult problem. On the other hand, evaluation of the educational program in terms of meeting the needs of the organization is more feasible. Such evaluation is based upon: 1. Establishing goals. 2. Establishing standards. 3. Comparing performance with the standards.

Goals, of course, are established by company deficiencies and needs. Standards provide a yardstick for measurement by comparison of actual performance with standard performance.

Basically, goals may be established in four broad areas:

1. Scope of training program
2. Administration of the training program
3. Teaching and learning process
4. Direct results

Standards, in turn, may be established in detail for these four broad areas by further development, Table 3.

The final phase of measurement is to evaluate performance for comparison with standards. Some courses can be evaluated only in terms of whether they did or didn't do the job. Most courses will demand a more sensitive measurement of how well the job was done. Table 4 suggests several methods for measuring relative achievement.

Fig. 3—Training program brochure.

amine the validity of various analytical procedures used to
interpret experimental results.

Time Requirements
Course length .....26 weeks
Class time .....2 hours per week
Outside study .....8-10 hours per week

Prerequisite
Statistical methods or equivalent.

Charge to Section
Approximately $15.

Course Content
1. Statistical inference
2. Precision and accuracy of data
3. Techniques for improving sensitivity
4. Experimental design
5. Confounding and partial replication
6. Sequential design procedures
7. Analysis of covariance

ELECTRONIC CIRCUITS

Purpose
To give engineers and scientists with basic electrical engineering training the tools for design work with conventional electronic circuits.

Time Requirements
Course length .....26 weeks
Class time .....2 hours per week
Outside study .....6-8 hours per week

Prerequisite
A background in electronics and a familiarity with the differential equations of ac circuit analysis.

Charge to Section
Approximately $80.

Course Content
1. Networks: Network theorems; resonant circuits
2. Amplifier principles: Voltage, power, and feedback amplifiers.
3. Transistors
4. Applications: Computer amplifiers and circuits; pulse and high-frequency systems, etc.

Purpose
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Charge to Sec...
Approximately $60.

Course Content
1. Potential flow
2. Viscous flow
3. Boundary-layer theory
4. Heat transfer
5. One-dim...
6. Thermodynamics
7. Fundamental equations
8. Linearized theory

NUMERICAL METHODS AND MATHEMATICAL ANALYSIS

Purpose
To develop the mathematical knowledge necessary for solving various problems amenable to numerical methods of analysis.

Time Requirements
Course length .....13 weeks
Class time .....3 hours per week
Outside study .....8-10 hours per week

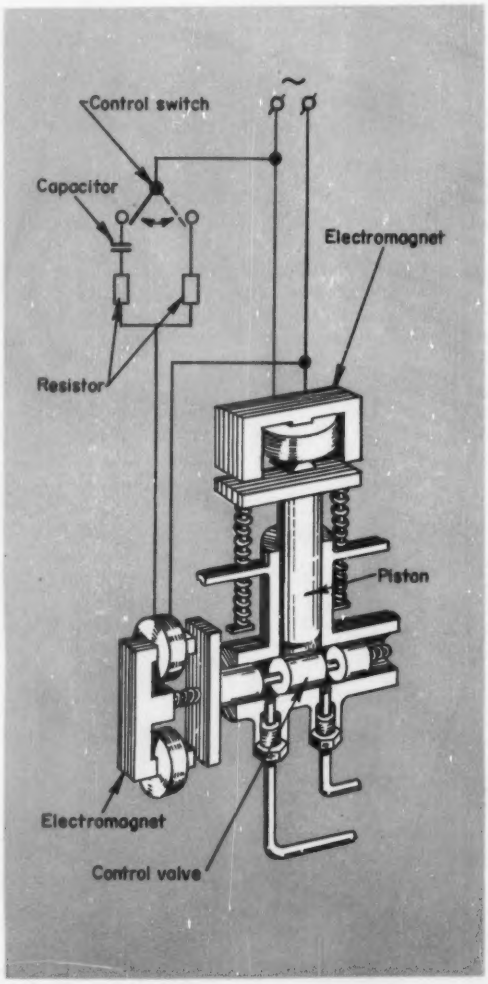
Prerequisite
A course in ordinary differential equations or its equivalent.

Charge to Section
Approximately $50.

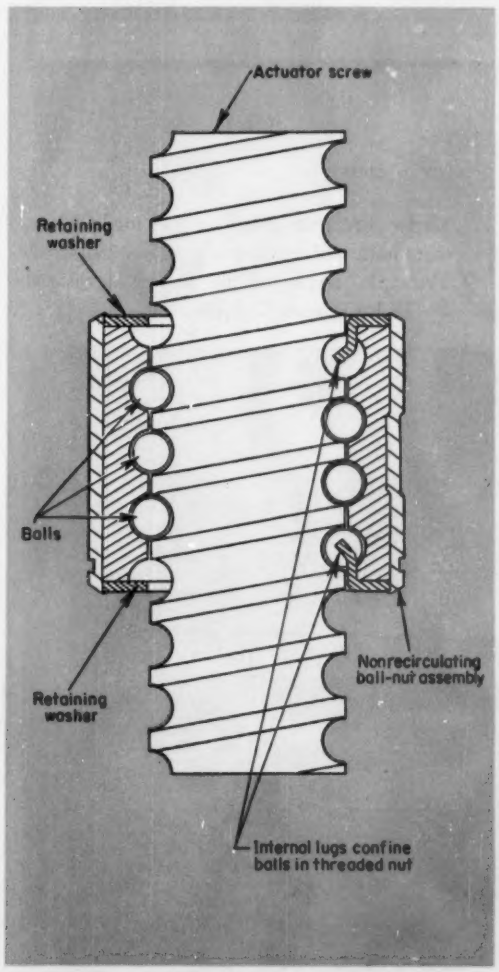
Course Content
1. Taylor series
2. Least-square polynominals

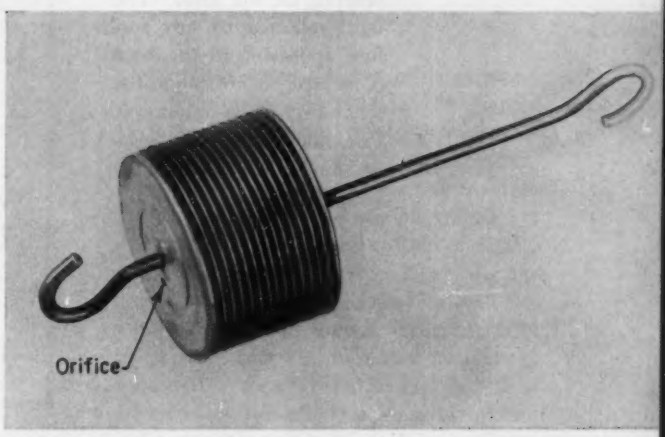
scanning the field for *ideas*

Out-of-phase valve controls direction of output flow of a pulsed hydraulic pump. A spring-suspended electromagnet, operated by 60-cycle ac power, actuates the pump piston. The same power supply actuates the spool-type control valve. Movement of the control-valve spool in relation to pump piston is controlled by adding resistance or capacitance in the control-valve circuit. Thus, a simple switching circuit controls the direction of pump output. Principle employed in device developed by Electro-Mechanik GmbH, Wendenerhuette ueber Olpe/Westf, Germany.



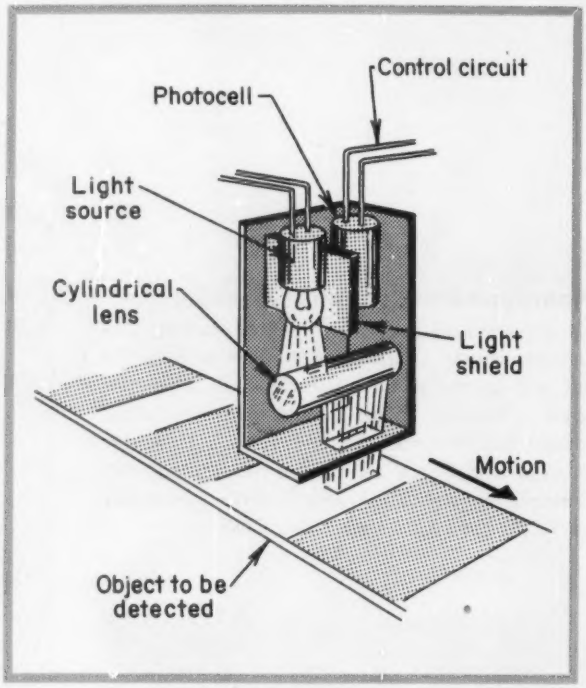
Nonrecirculating balls in a ball-nut assembly prevent load feedback force from turning the actuator screw. Contours of the ball races in the nut and on the screw rotate the balls when the screw is turned. Thus, the balls provide rolling contact between the nut and screw. However, an axial load on the nut cannot rotate the screw. Principle employed in control device developed by R.C.S. Tool Co., Van Nuys, Calif.



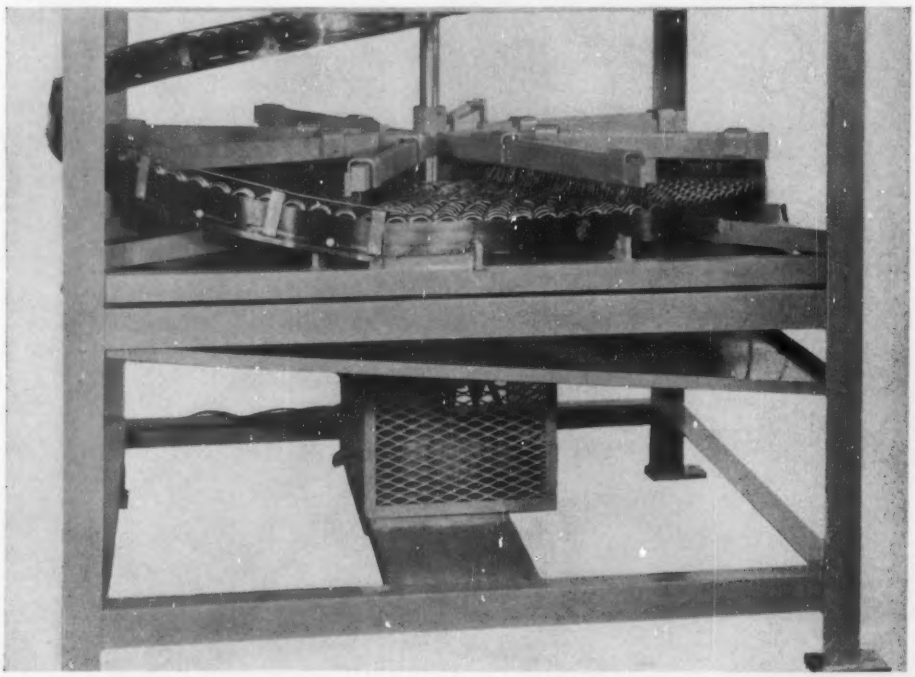


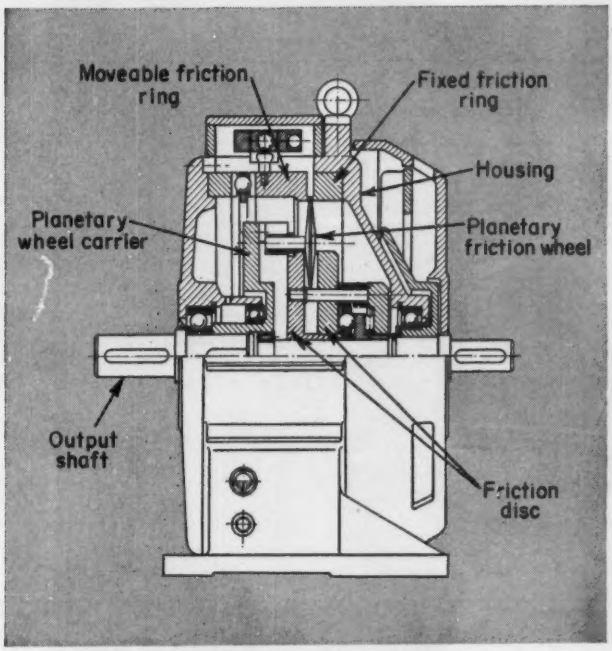
Submerged punctured bellows serves as a return spring as well as a vibration damper in a fuel-control system. The bellows is submerged in the fuel. A small orifice in each end of the bellows controls fluid flow to provide the damping. Principle employed in bellows developed by Metal Bellows Corp., Wellesley Hills, Mass.

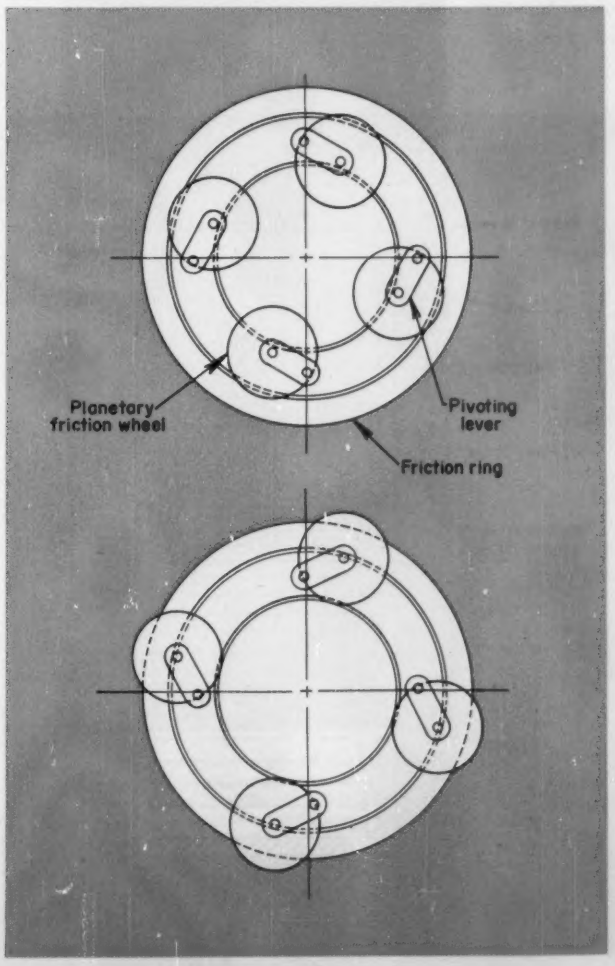
Cylindrical lens projects exciter beam and focuses reflected light in a photoelectric reader. The filament of the light source, arranged parallel to the length of the lens, is projected as a narrow line of light outside the aperture opening of the unit. The light reflected by any surface appearing in this area is focused back through the lens onto the photocell. Principle employed in reader developed by Melpar Inc., Falls Church, Va.



Powered pusher brushes urge along circular parts in a spiral feeder. Bristle resilience prevents damage to the parts by the moving brushes when the feeder becomes filled or jammed. Thus, automatic safety shut-off is not required. Principle employed in feeder developed by F. Jos. Lamb Co., Detroit.

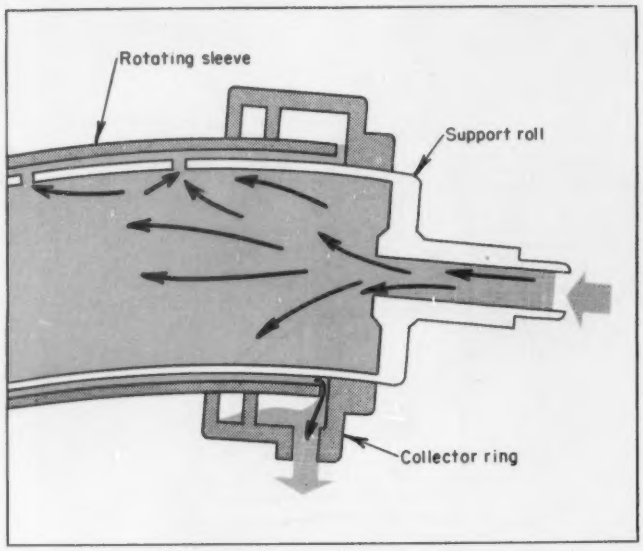




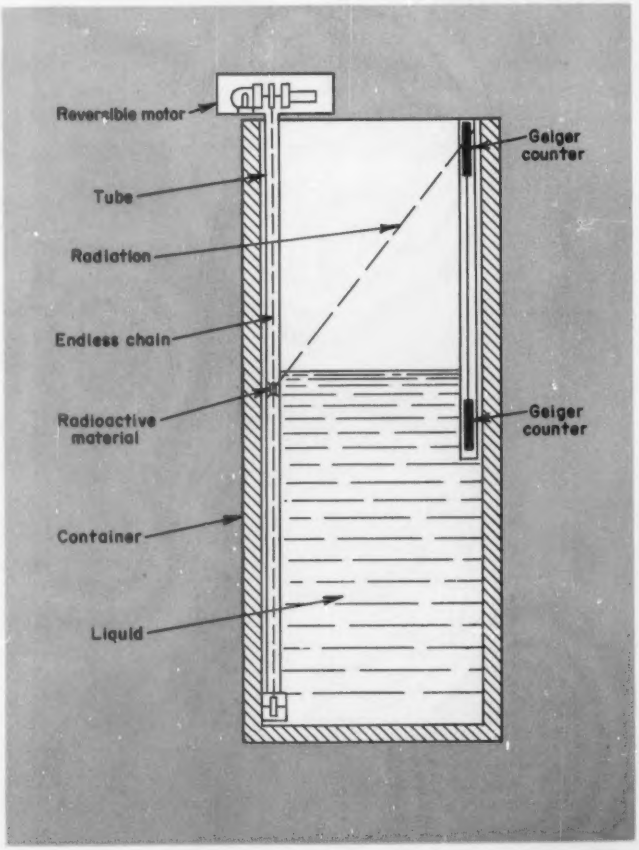


Stepless planetary adjustment of output speed is provided by pivoted double-cone friction wheels in a friction-drive transmission. A pair of axially adjustable friction discs serve as the sun gear; the double-cone friction wheels are the planet pinions; and a pair of axially adjustable, but nonrotating, friction rings are the ring gear. Co-ordinated axial movement of the friction discs and friction rings controls the radial position of the double-cone friction wheels, and thus determines the effective diameter of the planet-pinion carrier. Principle employed in transmission developed by Block and Vaupel, Wuppertal, Germany.

Curved fluid film provides continuous uniform support for a free running rubber sleeve on a bow expander roll. Pressure fluid supplied through the stationary support roll forms a fluid film between the curved roll and the rotating sleeve. Excess fluid is drained off through collector rings. Fluid-film support principle employed in bow expander roll developed by Rodney Hunt Machine Co., Orange, Mass.



Differences in shielding between liquid and air actuate control circuits to indicate liquid level in a container. The radioactive material is raised or lowered within a tube by a reversible motor and chain drive. Two Geiger counters measure radiation output. The output currents operate motor-reversing relays until the radioactive material is positioned at a height equal to the liquid level. A regular potentiometer is geared to the motor to operate an indicating circuit. Principle employed in depth indicator developed by Allgemeine Elektricitaets-Gesellschaft, Berlin, Germany.



New low - temperature - curing coatings apply Teflon's properties to parts that cannot take high temperatures. It's done by dispersing PTFE particles in a cellulosic or phenolic film. This article presents the characteristics of . . .

PTFE Dispersion Coatings

A. J. STOCK
Research and Development Manager
Acheson Colloids Co.
Port Huron, Mich.

Fig. 1—Low-power magnification of PTFE dispersion film shows that particles of PTFE float on the resin substrate. For this reason, a contacting resin system can wet the areas unprotected by PTFE.

HEAT-sensitive materials such as rubber and wood can be coated with Teflon, applied by a spray process and cured at room temperature. PTFE dispersions widen the use of PTFE for lubricating coatings appreciably, since the pure resin requires a sinter at 700 F.

Most PTFE-resin coatings consist of a single, thin film whereas pure polytetrafluoroethylene usually requires multiple coatings to prevent pinholes and to insure corrosion resistance.

PTFE-resin dispersions consist of two-component systems; 1. An "A" component, which is a combination of Teflon 30 plus additives for over-all compatibility. 2. A "B" component, which is a resin solution that provides desirable film and emulsification properties.

Dispersion Properties: Two PTFE-resin dispersions are currently available: 1. Phenolic-resin base. 2. Cellulosic-resin base. Physical properties of both dispersions are generally similar, Table 1, the main difference being in the curing cycles. The phenolic

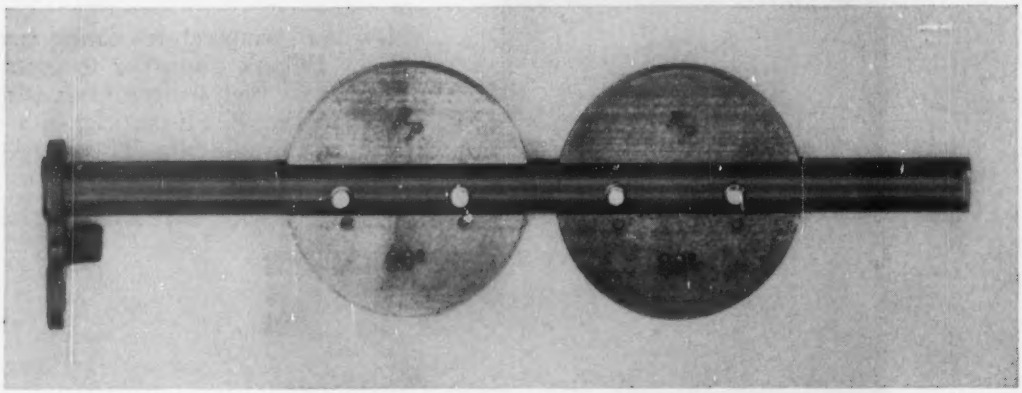


Fig. 2—Aluminum shaft of carburetor part is sprayed with PTFE-resin dispersion in critical bearing areas. The film affords long-life, oil-free lubrication.

Table 1—Properties of PTFE-Resin Dispersions

Property	Phenolic Resin System*	Cellulosic Resin System†
Ratio, resin/PTFE	1:1	1:1
Cure Temperature (F)	300	70
Cure Time (hr)	1	2
Flash Point (F)	48	40
Density (lb per gal)	8.2	7.9
Shelf Life at 70 F (mo)	2	2
Shelf Life at 40-50 F (mo)	4	4
Life, mixed, at 70 F (days)	2	4
Color	Blue	Blue

*Emralon 310. †Emralon 320.

Table 2—Properties of PTFE-Resin Films

Property	Phenolic Resin System*	Cellulosic Resin System†
Thickness, recommended (mil)	0.2-0.7	0.2-1.5
Temperature, max operating (F)	400	180
Flexibility, mandrel bend (in.)	¼	¼
Adhesion, in.-lb impact	28	28
Release Properties		
Water systems	Fair	Fair
Resin systems	Poor-Fair	Poor
Alpha Wear Life at 72 rpm and 150 lb load (cycles)	60,000	70,000
Color	Green	Blue

*Emralon 310. †Emralon 320.

Table 3—Chemical Resistance of PTFE-Resin Films

Chemical Exposure	Phenolic Resin System*	Cellulosic Resin System†
Salt Spray, 20 per cent (hr)		
On steel	600	200
On aluminum	2000	500
Nitric acid (hr)	40	20
Chromic acid (hr)	120	40
Oxalic acid (hr)	450	450
Ammonium hydroxide (hr)	20	20
Methyl isobutyl ketone	No effect	Fails
Acetone (hr)	90	Fails
Lactol spirits	No effect	Color fades, film O.K.
Toluol (hr)	90	Fails
Hydrochloric acid (hr)	30	45
Sulfuric acid (hr)	100	300
Acetic acid (hr)	70	45
Sodium hydroxide (hr)	1450	800
Liquid oxygen	No effect	No effect
Unsymmetrical dimethyl hydrazine	No effect	Fails
Hydrogen peroxide	No effect	Fails

*Emralon 310. †Emralon 320.

system requires a cure at 300 F for 1 hr, and the cellulosic system cures at room temperature in 2 hr.

Film Properties: Thin films of PTFE-resin dispersions combine the excellent lubricating characteristics of a dry film with the protective quality of a bonding resin. In its pure form, PTFE has the lowest coefficient of friction of any known plastic material. The resin tends to raise this coefficient slightly, but the values are still desirably low.

Dry film thicknesses normally are in the range of 0.2 to 0.7 mil, Table 2—considerably thinner than usual protective coating systems. This puts the burden on the resin component of the formulation to provide proper chemical resistance.

Adhesion and flexibility properties of both the phenolic and the cellulosic coatings are as good as those of most paint films for relatively rigid substrates. The phenolic system can be used also on moderately flexible rubber parts. Release properties of the coatings are not as good as those of pure PTFE, however, because contacting systems can bond to the resin substrate of the film.

Compared with graphite or molybdenum-disulfide films, the PTFE products do not have long wear lives. In general, PTFE lubricating films are designed for different wear conditions and are normally used for considerably lower loadings and lower speeds than other dry-film lubricants. PTFE films are recommended for applications where loading characteristics are not severe and where the need for a clean, dry film is essential.

Both the phenolic and the cellulosic coatings have excellent salt-spray resistance, but their chemical resistance depends greatly on the resin involved, Table 3. Corrosion resistance of the films can be improved with proper substrate pretreatment such as phosphating or anodizing. These coatings are not recommended as substitutes for pure PTFE where chemical resistance is the desired property. Rather, they are to be used where the lubricating property is the main requirement.

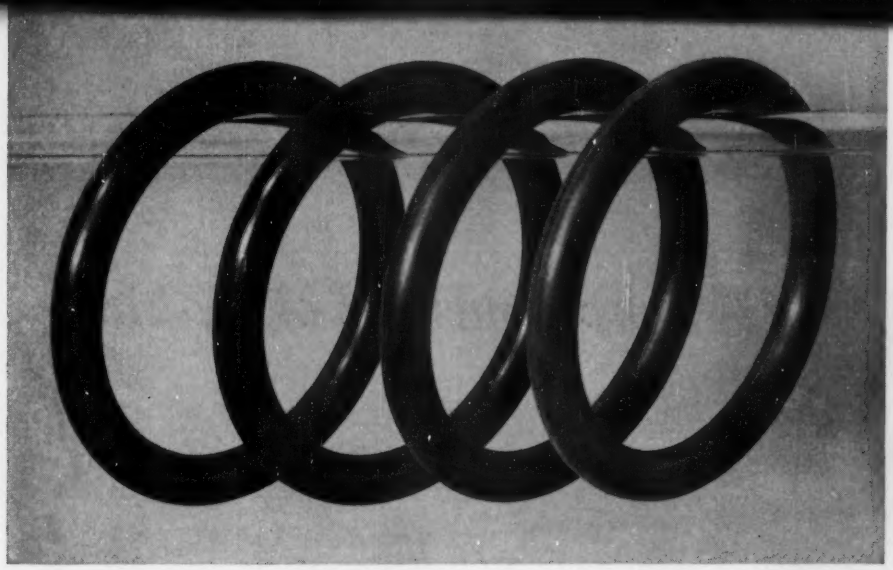


Fig. 3—Phenolic PTFE coating on the two O-rings at left maintains lubrication and nonsticking properties despite long periods of storage. The two rings at right are uncoated.

Application: PTFE dispersions are mixed (A and B components) just prior to being applied to surfaces.

Phenolic PTFE dispersion must be applied by spray techniques. Other methods such as dipping, swabbing, or brushing cause PTFE particles to flocculate and to form strings.

After being sprayed, the coating is allowed to dry to touch, and then is cured at 300 F for 1 hr. Completeness of the cure is indicated by a color change from blue to green.

Cellulosic PTFE dispersion is more stable than the phenolic and can be applied by spray, dip, or brush. The coating is then air dried for 2 hr at about 70 F to provide the required cure. A slight warming—not over 150 F—shortens curing time.

Heavy films can be built up with either dispersion by multiple coatings, air dried between coats. This technique is recommended rather than that of using one heavy coat. Electrostatic spray methods may be employed to reduce overspray if the substrate will accept an electrostatic charge. Multicoat PTFE-resin dispersions result in a smooth, continuous film of good lubricity and corrosion resistance.

Present and Future Uses: Current uses of PTFE-resin films include coatings for camera, business-machine and similar parts where loadings are low and where low-friction surfaces are required. The nonsticking properties of PTFE surfaces applied to conveyor belts help keep surfaces clean in food machinery and other industrial equipment.

Experimental systems for PTFE-resin dispersions include the use of silicone, epoxy, and polyurethane bases. Dispersion systems are being developed that will improve present characteristics of flexibility, color availability, and light sensitivity.

Tips and Techniques

Oblique Triangle Solution

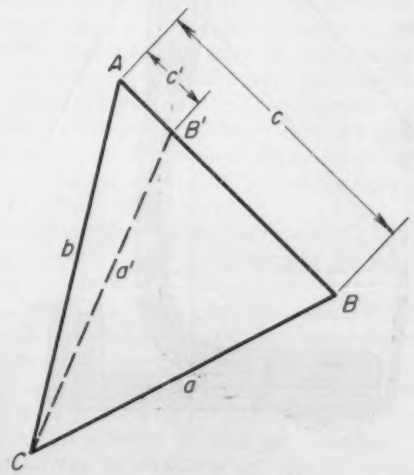
When two sides of an oblique triangle and the angle opposite one of them is known, a direct solution for the unknown side can be made from

$$c = b \cos A \pm \sqrt{a^2 - b^2 \sin^2 A}$$

where sides a and b, and angle A are known.

Example: In the figure, $a = 11$; $b = 12$; angle $A = 60$ deg. Solving, $c = 9.6$ or 2.4, which determines both of the possible triangles, ABC and $AB'C$.

—Frank Murray, *Detroit, Mich.*



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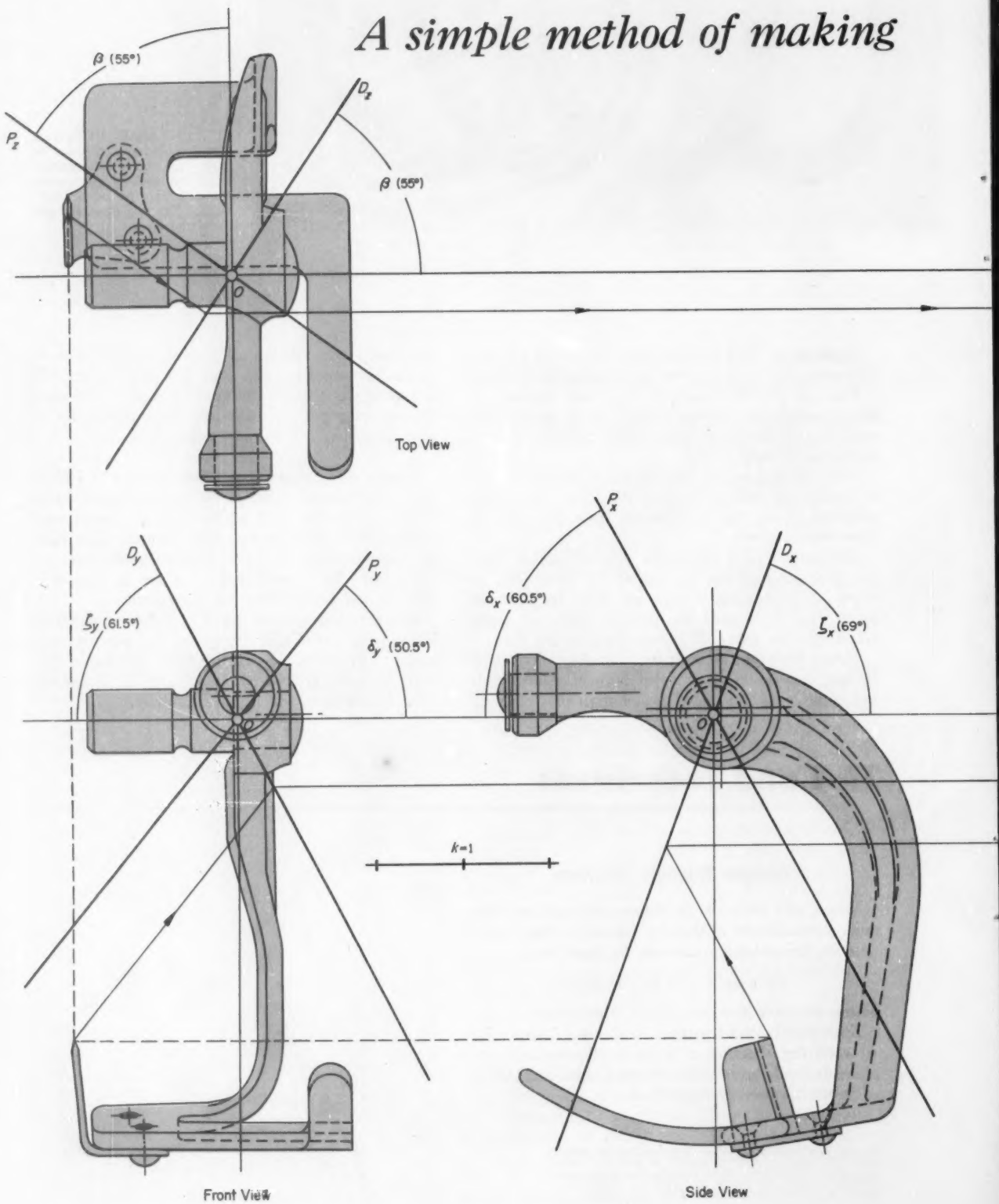
A simple method of making



PICTORIAL DRAWINGS

by direct projection from engineering views

JANUSZ LANGE
Wroclaw, Poland

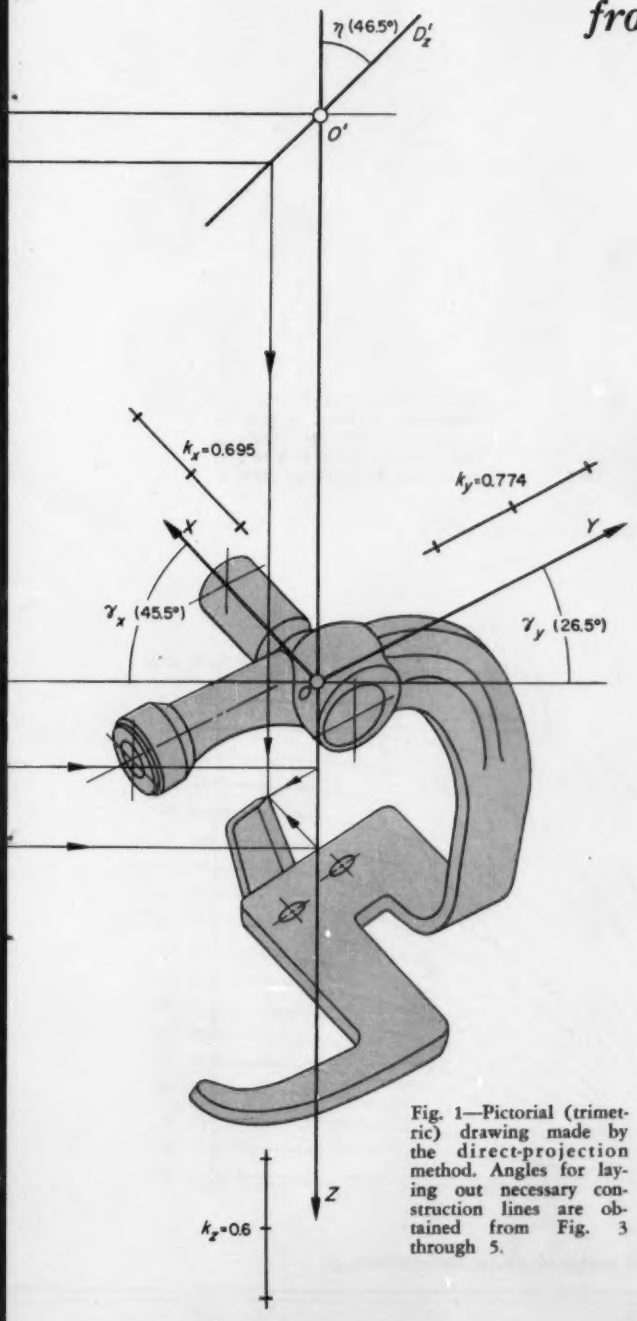


Fig. 1—Pictorial (trimetric) drawing made by the direct-projection method. Angles for laying out necessary construction lines are obtained from Fig. 3 through 5.

A PICTORIAL view added to ordinary orthographic drawings of a part helps greatly in visualizing its shape. Use of a pictorial view can lead to real (although not readily calculable) savings in production costs.

The more awkward the shape of an object, the more desirable the pictorial view on an engineering drawing. Unfortunately, for a complex object, a pictorial view is difficult to make by ordinary "dimension transfer" methods. Often, only an especially gifted draftsman can do the job.

The easiest types of pictorial views to make are axonometric drawings, and especially isometric drawings. While isometrics are easy to draw, they are usually not the best to demonstrate the true shape of the object. Trimetric and dimetric views are better. But, even when made by projection from orthographic views, they require much copying work, and the identification of points is tiresome, difficult, and may easily lead to errors.

This article presents a new, universal, fully graphical, and comparatively simple method for directly projecting a pictorial view from common engineering drawings, called the "direct-projection method." The view may be any of the axonometric types—trimetric, dimetric, or even isometric. Points on the pictorial view are plotted by projection from unmoved orthographic views, and the pictorial view may be made directly on an existing engineering drawing.

The object can be shown in any desired position, and may be shown in any size as compared with the

orthographic views (theoretically from zero to infinity). The method, and the work involved, are the same in any case.

Making the Drawing

First step in the direct projection method is to select some point on the object as the origin O of a set of co-ordinates, Fig. 1.

By methods shown later, the following construction lines are drawn:

1. Axes OX, OY, OZ through the origin at the point where the pictorial view is to be drawn.
2. Projector lines P_x, P_y, P_z.
3. Director lines D_x, D_y, D_z, D'_z. Director line D'_z is drawn through the "point of turn," O'.

The position of every point on the object may now be found graphically. From the three projec-

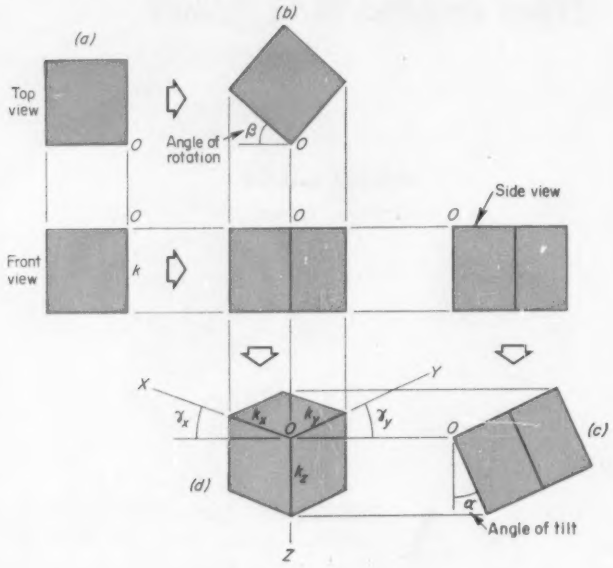


Fig. 2—Development of an orthographic drawing, *a*, into an axonometric drawing. Cube is first rotated, *b*, then tilted, *c*, to develop the pictorial view, *d*.

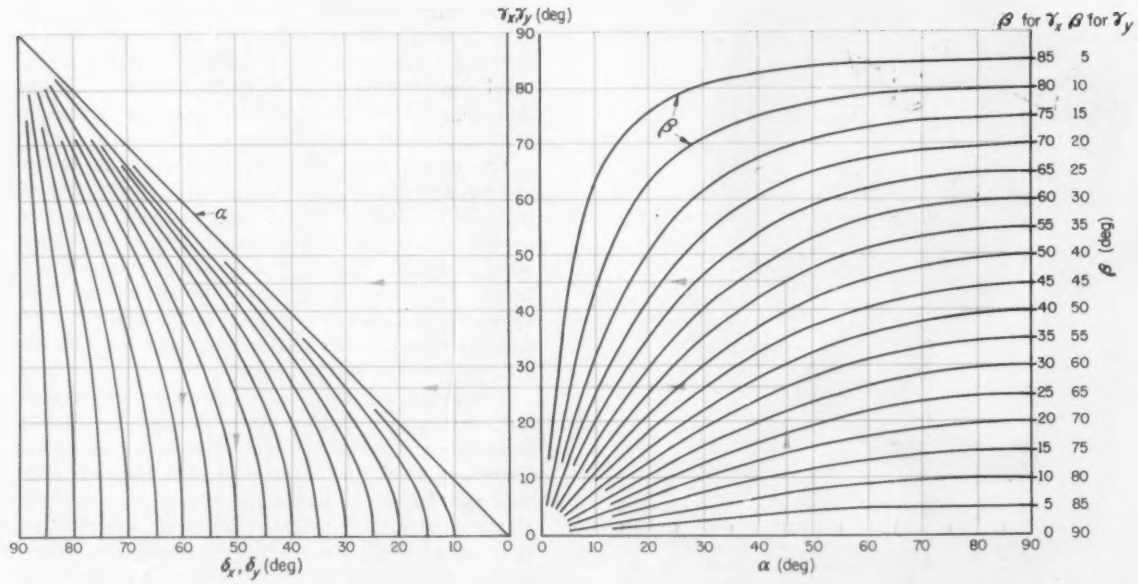


Fig. 3—Determination of angles γ and δ from known angles of tilt, α, and rotation, β.

tions of the point in the orthographic views, lines are drawn parallel to projector lines P to intercept director lines D. They are then drawn horizontal or vertical to intercept axis OZ (or director line D'_z) and finally parallel to axes OX, OY, or OZ. Intersection of the three lines locates the point.

In practice, the axonometric drawing is made by using only two orthographic views (front and side, or front and top). Thus, only two sets of lines will be required. Also, only vertical axis OZ and three director lines D must be drawn in full length. Axes OX and OY, and projector lines P, need only be

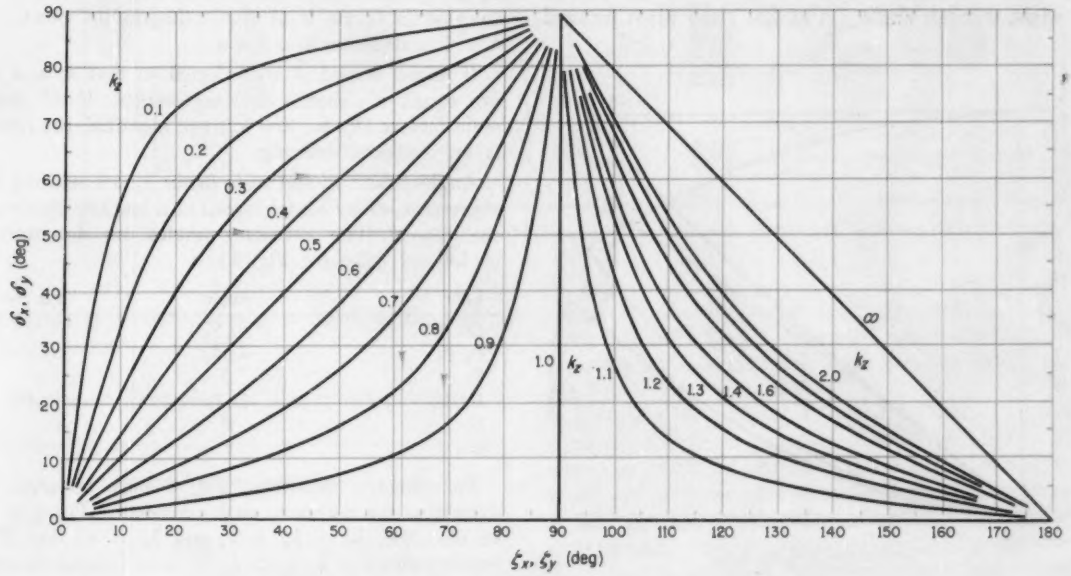


Fig. 4—Determination of angles ξ from angle δ and scale factor k_z.

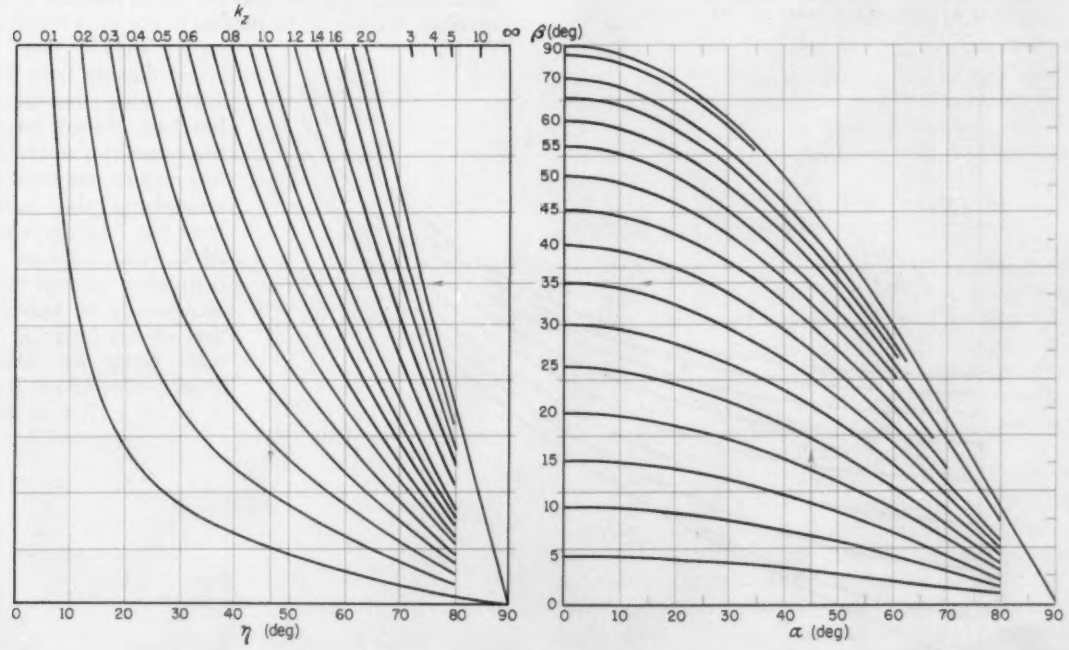


Fig. 5—Determination of angle η from angles α and β and scale factor k_z.

marked with short dashes. The two lines first projected need not be traced full length; short dashes marking their intercept with the director lines are sufficient.

Constructing the Projection Lines

Fig. 2 shows how an axonometric view originates. First, look from infinity at the front face of a cube, Fig. 2. Rotate the cube around one of its vertical edges through angle β, Fig. 2*b*. Then tilt it forward to angle α with the vertical, Fig. 2*c*. This gives the axonometric view of the cube, Fig. 2*d*.

Angles γ_x and γ_y, and thus all other angles which determine projector and director line directions, depend on values of angles α and β. These two angles, therefore, must first be decided upon.

If the cube is tilted and rotated, all its three edges will appear foreshortened, and scale factors k_z, k_x, k_y along three axonometric axes will all be smaller than scale factor k of the orthographic views. If $k = 1$, scale factor $k_z = \cos \alpha$.

If angles α and β are selected so that k_x and k_z are equal, a dimetric drawing results. If all three scale factors (k_z, k_x, and k_y) are identical, the result is an isometric drawing.

Angles α and β, and scale factor k_z, are selected by experience, or by a trial layout of a few key points on the object. The necessary angles are determined as follows (also see Fig. 1):

Line	Angle	Fig. No.
OX, OY	γ_x, γ_y	3
P_x, P_y	δ_x, δ_y	3
P_z	β	—
D_x, D_y	ζ_x, ζ_y	4
D_z	β	—
D'_z	η	5

For dimetric drawings, Fig. 6 may be used to determine the necessary angles instead of Fig. 3 to 5. In this case, $k_z = k_x = 1$, and $\delta_y = 45$ deg. Dimetric index $s = k_y/k_z = k_y/k_x$ must first be chosen, after which other angles are automatically fixed.

In some cases, it may be handy to know the scale factors along axes OX and OY (although this is not necessary for use of the method). For $k_z = 1$, values for k_x and k_y may be found directly from Fig. 7. If a value other than 1 has been chosen for k_z, the other two scale factors may be computed by multiplying the values from Fig. 7 by the selected k_z value.

Another concept may occasionally be handy—that of size factor n. If scale factor for orthographic views $k = 1$, then $k_z = \cos \alpha$. If k_z is then

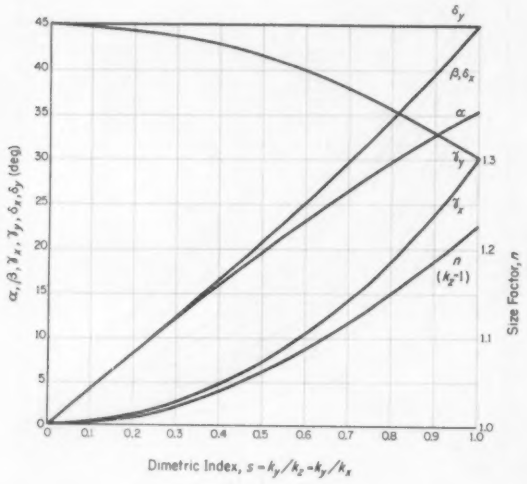


Fig. 6—Simplified method for determining construction angles for dimetric drawings when $\delta_y = 45$ deg and $k_y = k_z = 1$. Necessary angles may be read off directly by selecting a value for the dimetric index.

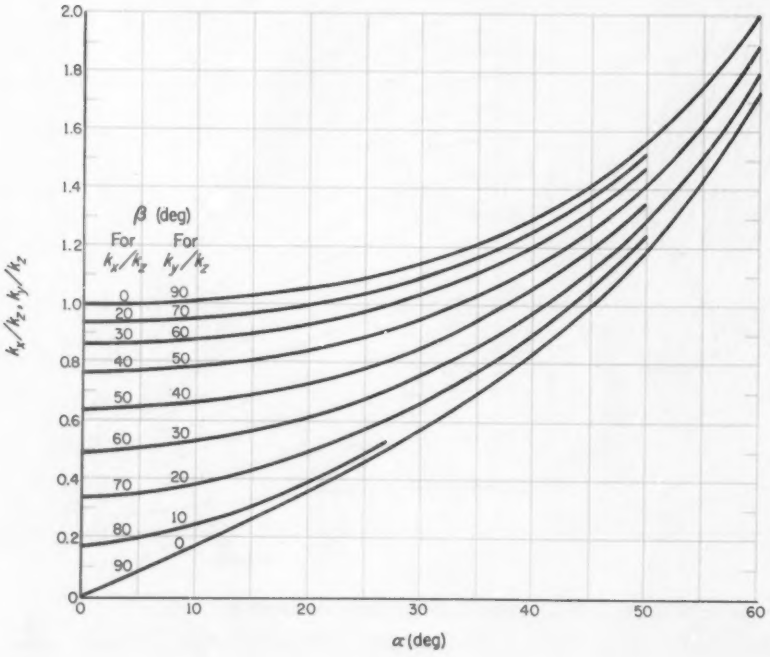


Fig. 7—Finding scale factors k_x and k_y from known angles α and β and selected scale factor k_z.

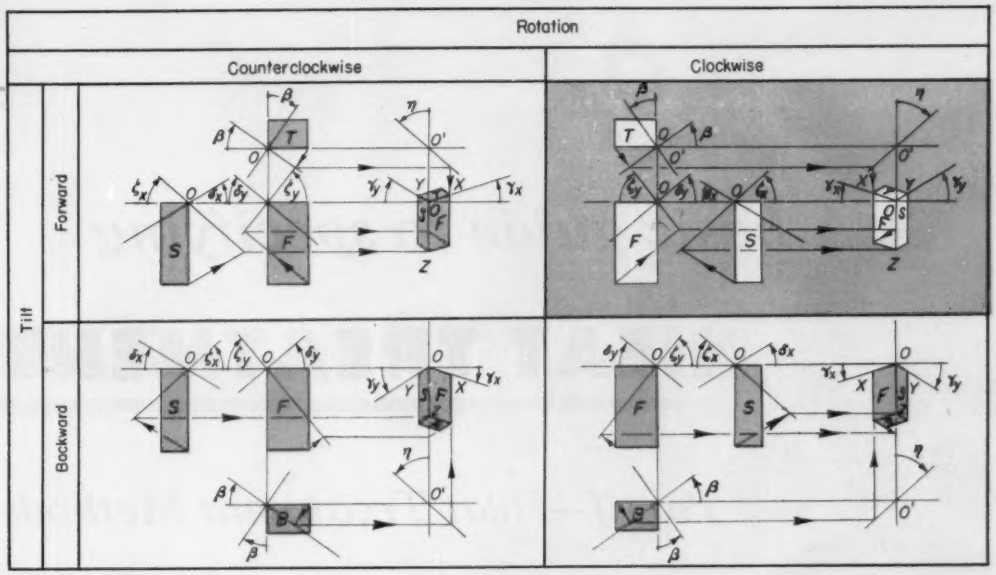


Fig. 8—Placement of construction angles and lines for different views.

increased to 1, size factor $n = 1/\cos \alpha$. Generally, the size factor $n = k_z/\cos \alpha$.

Numerical Example: For the drawing in Fig. 1, values of $\alpha = 45$ deg, $\beta = 55$ deg, and $k_z = 0.6$ were selected. Fig. 3 through 7 show angles and scale factors determined (values are also shown on Fig. 1).

From Fig. 7, $k_x/k_z = 1.16$ and $k_y/k_z = 1.29$ are determined. These must be multiplied by 0.6 to arrive at actual values: $k_x = 0.695$ and $k_y = 0.774$. Main use of these two values is to find ellipse sizes in the pictorial view. Actual circle diameter in the orthographic view is multiplied by the appropriate scale factors to obtain the ellipse major and minor diameters.

Reference Equations

For Fig. 3

$$\gamma_x = \sin \alpha \tan \beta \qquad \gamma_y = \frac{\sin \alpha}{\tan \beta}$$

$$\delta_x = \gamma_x + \arcsin \frac{\sqrt{\tan^2 \gamma_x + \sin^2 \alpha} - \cos \alpha \tan \gamma_x}{1 - \tan^2 \gamma_x}$$

$$\delta_y = \gamma_y + \arcsin \frac{\sqrt{\tan^2 \gamma_y + \sin^2 \alpha} - \cos \alpha \tan \gamma_y}{1 - \tan^2 \gamma_y}$$

For Fig. 4

$$\zeta_x = \arctan \frac{k_z}{1 - k_z} \tan \delta_x$$

$$\zeta_y = \arctan \frac{k_z}{1 - k_z} \tan \delta_z$$

For Fig. 5

$$\eta = \arctan \frac{k_z}{\cos \alpha \sin \beta}$$

For Fig. 6

$$\alpha = \arcsin \frac{s}{\sqrt{2 + s^2}} \qquad \beta = \arcsin \frac{s}{\sqrt{2}}$$

$$\gamma_x = \arctan \frac{s^2}{\sqrt{4 - s^4}} \qquad \gamma_y = \arctan \sqrt{\frac{2 - s^2}{2 + s^2}}$$

$$\delta_x = \beta \qquad \delta_y = 45 \text{ deg} \qquad n = \frac{1}{\cos \alpha}$$

For Fig. 7

$$\frac{k_x}{k_z} = \frac{\sqrt{1 - \cos^2 \alpha \sin^2 \beta}}{\cos \alpha}$$

$$\frac{k_y}{k_z} = \frac{\sqrt{1 - \cos^2 \alpha \cos^2 \beta}}{\cos \alpha}$$

Alternate Positions: Although the most common pictorial drawing is based on a clockwise rotation and forward tilt (as in Fig. 1), other positions may be desired. Methods of finding angles and scale factors are exactly the same as just described. But location of the pictorial drawing changes, as do locations of the angles and lines. Fig. 8 shows the proper locations.

Practical Considerations

The direct-projection method is characterized by the necessity of drawing inclined lines in cyclical sequence. This work can be done conveniently with four adjustable triangles set at proper angles—for example δ_y, δ_z, γ_y, γ_z. They are used in sequence.

Other methods are to use two special double-angled triangles made from plastic, or specially cut drawing boards with ordinary T-squares.

With every drawing except a simple one, the work is started by using the direct-projection method to plot co-ordinate axes, projector lines *P*, and director lines *D*. Then some main points of the axonometric drawing are plotted with this method.

All easier portions of the drawing may then be made with ordinary "dimension-transfer" methods since these methods will probably be quicker. More difficult portions (curved and slanted lines) can be made by the direct-projection method.

A basic guide to specifying

HEAT TREATMENT OF

Part 1—Heat Treatment Methods

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STEEL is an important engineering material largely because of the variety of physical and mechanical properties obtainable through heat treating. Such standard procedures as normalizing, annealing, hardening and tempering, and the newer isothermal treatments offer a wide range of end properties when applied to properly selected steel analyses.

This article, first of a two-part series, is a design guide to the specification of standard heat-treating processes for carbon and alloy steels.

Commercial Steels

Carbon is, of course, the predominant element that establishes the analysis of a carbon steel. An alloy steel, on the other hand, contains such elements as nickel, chromium, molybdenum, or vanadium, which usually perform one or more of three functions: 1. Improve mechanical properties at room, elevated, or low temperatures. 2. Increase resistance to chemical attack or to high-temperature oxidation. 3. Impart special properties, for example, the magnetic characteristics of silicon-electrical steels.

Although each alloying element has certain effects on basic characteristics of a family of steels, Table 1, the effects of any one element are interrelated with and dependent upon those of other elements in the analysis. This interrelationship of alloying elements must be carefully considered so that the beneficial effects of each are used to best advantage. For example, in a chromium-nickel alloy steel, the chromium provides excellent hardenability, the nickel, ductility. In a chromium-molybdenum alloy steel, the over-all characteristics include excellent hardenability, fair ductility, and fair heat resistance.

Single-alloy steels are generally used in smaller sections—up to about 2 in. in diameter or section—where thorough hardening and suitable mechanical properties can be obtained in subsequent tempering operations. For heavier sections, where greater depth-hardening characteristics are desired, double or triple-alloy steels are usually necessary to obtain the required hardenability.

Heat-Treatment Processes

Steel is polymorphic; that is, it has the ability to exist in more than one crystallographic structure. The change from one structure to another takes place in the solid state—both on heating to a transformation temperature and on cooling from this temperature. Heat-treatment processes use this reversible reaction—allotropy—to obtain specific mechanical properties, to improve machinability, or to obtain desired microstructures.

An important tool, used to predict the behavior of a steel during heat treatment, is the isothermal

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STEELS

diagram. The diagram, based on microstructure, varies in configuration with transformation temperature (Ae_3), chemical composition, and grain size of the material. The isothermal diagram is essentially a road map, used to plan a heat treatment.

Normalizing: When steel is hot-worked from an ingot to a finished product or forged or cast into a shape, the resulting grain structure of the metal is not uniform. This characteristic is often accompanied by chemical segregation in some areas and by nonuniform stress distribution. The extent of the last two conditions depends basically on the cooling rate used and on physical shape of the product. A corrective treatment for these conditions is normalizing, particularly where the part will be subsequently heat treated to a specified hardness condition. A typical normalizing treatment, Fig. 1*a*, consists of: 1. Heating to about 100 F above the transformation range of the material. 2. Soaking to permit formation of a uniform austenite throughout the section thickness. 3. Air cooling.

For sections that have been severely coarsened (grain size) during hot working, a double normalizing element may be necessary to promote a uniform response to subsequent heat treatments.

Because of the relatively rapid air-cool phase of the normalizing cycle, the end product consists of ferrite, pearlite, and bainite. The first two are formed as the steel cools from the Ae_3 temperature to ap-

Table 1—Various Elements Used in Steel

Element	Function
Carbon	Increases hardness and strength parameters. Rate increase in as-rolled and normalized steels is steady to about 0.85 per cent carbon, above which the rate increase diminishes. A rapid increase of hardness and strength also occurs in the as-quenched condition to about 0.60 per cent carbon, above which the rate increase diminishes. The increase of these properties is normally accompanied by a decrease in ductility and weldability. Carbon has a tendency toward segregation within the ingot, objectionable because of major effects on properties.
Manganese	Increases strength and hardness parameters and decreases ductility and weldability, but to a lesser degree than carbon. Manganese is an essential addition to all steels, since it counteracts the effect of sulfur and thus improves hot-working characteristics.
Sulfur	An undesirable element except when added for improving machinability. Sulfur decreases transverse ductility, impact strength, weldability, and impairs surface quality. Sulfur has a strong tendency to segregate within the ingot.
Phosphorus	An undesirable element except when added to improve machinability or resistance to atmospheric corrosion. Although phosphorus increases strength and hardness to about the same degree as carbon, it also decreases ductility and toughness or impact strength, particularly in the quenched and tempered conditions.
Silicon	A deoxidiser. Although rimmed and capped steels contain no significant amounts, semikilled steels may contain up to 0.10 per cent silicon, and killed steels, up to 0.60 per cent. As an alloying addition, in amounts to 2.5 per cent, silicon increases strength without decreasing ductility. In larger quantities, silicon increases resistance to scaling at elevated temperatures, decreases machinability, and increases susceptibility toward decarburization.
Copper	Added only when improved resistance to atmospheric corrosion is desired. Although it normally has little influence on mechanical properties, copper promotes hot-shortness, thereby adversely affecting surface quality.
Nickel	Improves toughness (particularly at low temperatures), simplifies heat treatment, permits a mild quenching medium, and when present in appreciable amounts, it improves corrosion resistance.
Chromium	Essentially a hardening element. It increases depth hardness, improves abrasion resistance, and promotes carburization.
Molybdenum	Increases hardenability and is used when close hardenability control is required. It increases high-temperature tensile and creep strengths, and reduces susceptibility toward temper brittleness.
Vanadium	Reduces grain size and improves hardenability and creep strength at elevated temperatures.
Boron	Added to steel mainly to improve hardenability, particularly in fine-grained alloy steels.
Aluminum	Used as a deoxidizer and to control grain size. It is effective in obtaining high hardness in nitriding steels. Under certain conditions, aluminum promotes graphitization.

proximately 1000 F, and the bainite is formed as the transformation continues through the 1000 to 500 F range.

Annealing: The "full anneal" is used where full recrystallization of the grain is required to improve ductility, toughness, or electrical or magnetic properties. The full-anneal cycle, Fig. 1*b*, consists of: 1. Heating to above the Ae_3 temperature. 2. Soaking at this temperature. 3. Cooling at a controlled rate.

Since annealing involves a controlled-cooling rate, the temperature of the surface and that of the center of a piece are theoretically the same. A more uniform structure results throughout an annealed sec-

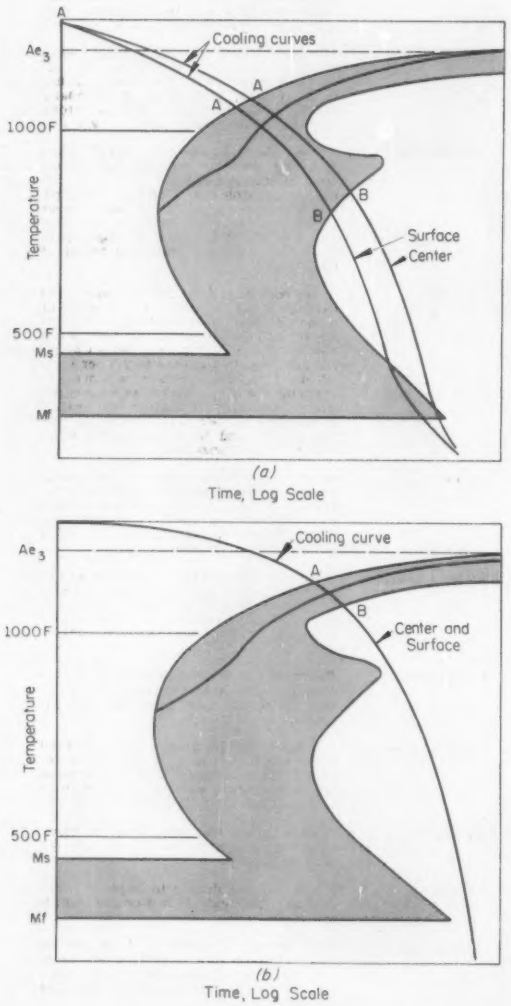


Fig. 1—Transformation diagrams[1] for, *a*, normalizing (ferrite, pearlite and bainite); *b*, full annealing (ferrite and pearlite).

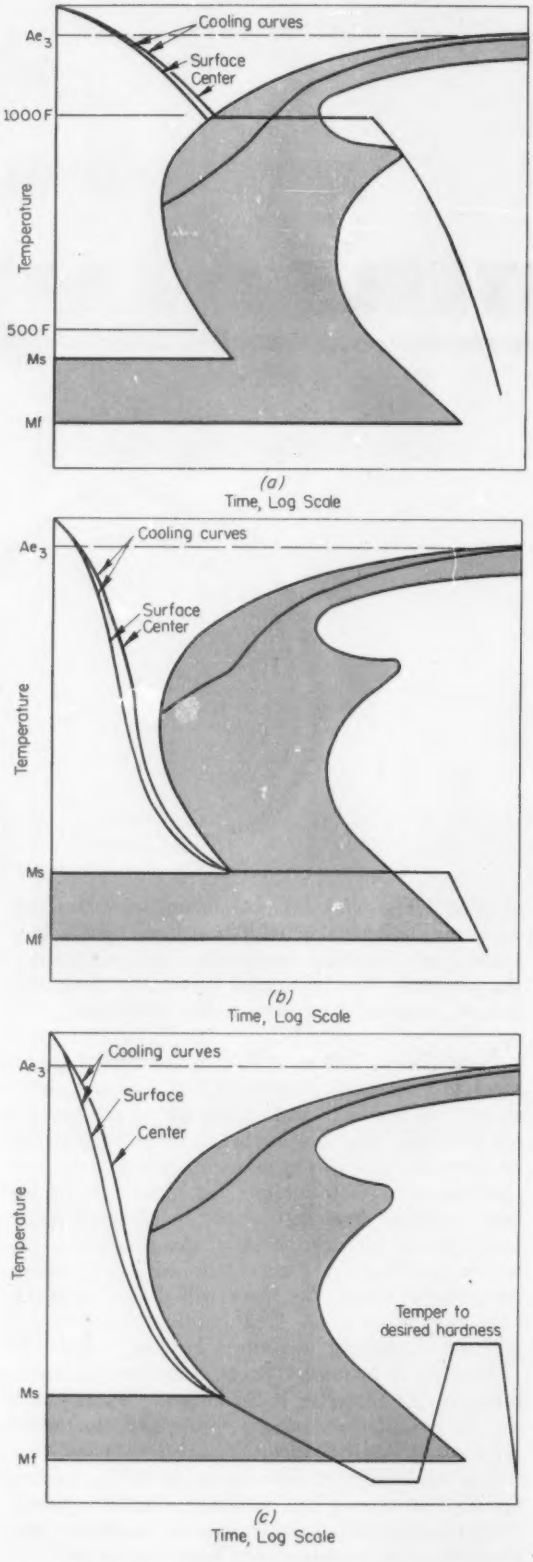


Fig. 2—Transformation diagrams[1] for *a;* isothermic annealing (ferrite and pearlite); *b*, austempering (bainite); *c*, martempering (tempered martensite). Ms and Mf represent the temperatures of start and finish respectively of transformation to martensite during cooling.

Table 2—Effects of Alloying Additions on Hardenability*

Steel	Alloying Addition (per cent) Carbon	Manganese	Chromium	Nickel	Molybdenum	Cooling Rate at 1300 F (deg per sec) 190	43.9	21.8	12.5	8.4	6.2	5.0	4.35
						Hardness, Rockwell C							
1040	0.36-0.44	0.60-0.90	.....	.....	.....	42	27	22	..	..	..	..	..
5140	0.38-0.43	0.70-0.90	0.70-0.90	.....	.....	54	45	36	32	29	27	25	22
1340	0.38-0.43	1.60-1.90	.....	.....	.....	55	48	40	35	32	30	29	28
8640	0.38-0.43	0.75-1.00	0.40-0.60	0.40-0.70	0.15-0.25	56	50	43	37	35	33	32	32
3140	0.38-0.43	0.70-0.90	0.55-0.75	1.10-1.40	.....	57	52	45	40	37	35	33	33
4140	0.38-0.43	0.75-1.00	0.80-1.10	.....	0.15-0.25	57	54	50	45	42	40	38	37
4340	0.38-0.43	0.60-0.80	0.70-0.90	1.65-2.00	0.20-0.30	59	56	55	53	53	53	52	49

*Data apply to carbon steels, 0.40 per cent carbon. Data from Reference 2.

tion as compared to a normalized one.

In terms of microstructure produced, cooling in an annealing cycle is sufficiently delayed so that the beginning and end of transformation is above 1000 F, where the softer transition products, ferrite and pearlite, are formed.

Stress-Relief Anneal: To relieve residual stresses induced by normalizing, machining, or cold working, a stress-relief anneal—at 1000 F or less—is often necessary. The part is heated slowly to the stress-relieving temperature, maintained at that temperature, then air cooled.

Spheroidizing Anneal: A heat treatment employed to improve certain cold-forming operations and machinability of the higher-carbon alloy steels is the spheroidizing anneal. The treatment consists of heating and soaking the steel slightly above or slightly below the lower critical temperature (Ae_1—about 1300 F for most alloy steels) to permit the spheroidization of the carbides, then cooling to room temperature.

Cyclic Anneal: Although the full anneal is reliable, it is slow because of the long cooling cycle. The faster cycle-anneal—an isothermal process—is often used to save time. The cooling phase is done in a molten-salt bath or a controlled furnace at a constant temperature within the ferrite-pearlite range until full transformation has taken place, Fig. 2*a*. Compared to a full-annealed part, a cyclic-annealed section will have a more uniform microstructure at a given hardness level. Steels treated with this process include alloys of chromium-molybdenum (AISI 40xx), molybdenum (AISI 44xx), nickel-molybdenum (AISI 46xx and 48xx), and chrominum-nickel-molybdenum (AISI 47xx, 86xx, 87xx, and 88xx)—all within a carbon range of 0.12 to 0.25 per cent.

Austempering: A hardening operation in which the quenching is done at an isotherm in the bainitic region (below 1000 F and above the Ms temperature) is called austempering, Fig. 2*b*. When material type and section size permit, the advantages of this treatment over the standard quench-and-

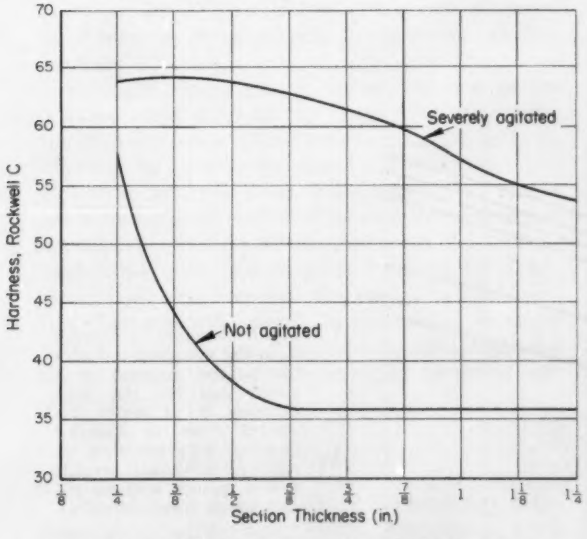


Fig. 3—Agitation of a molten-salt bath permits martempering heavier sections than a non-agitated bath. Curves show hardening response of AISI 52100 steel.

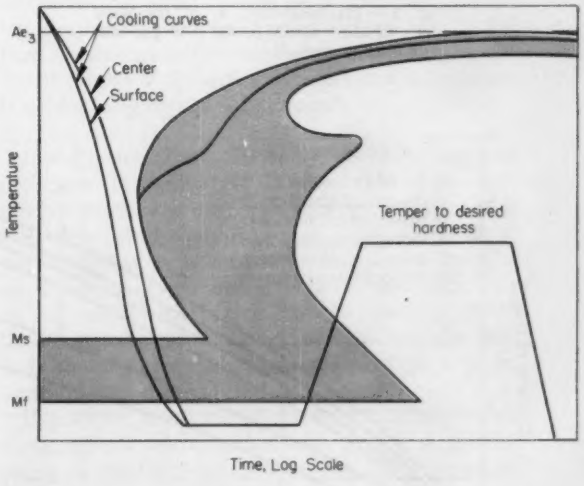


Fig. 4—Transformation diagram for quenching and tempering.[1]

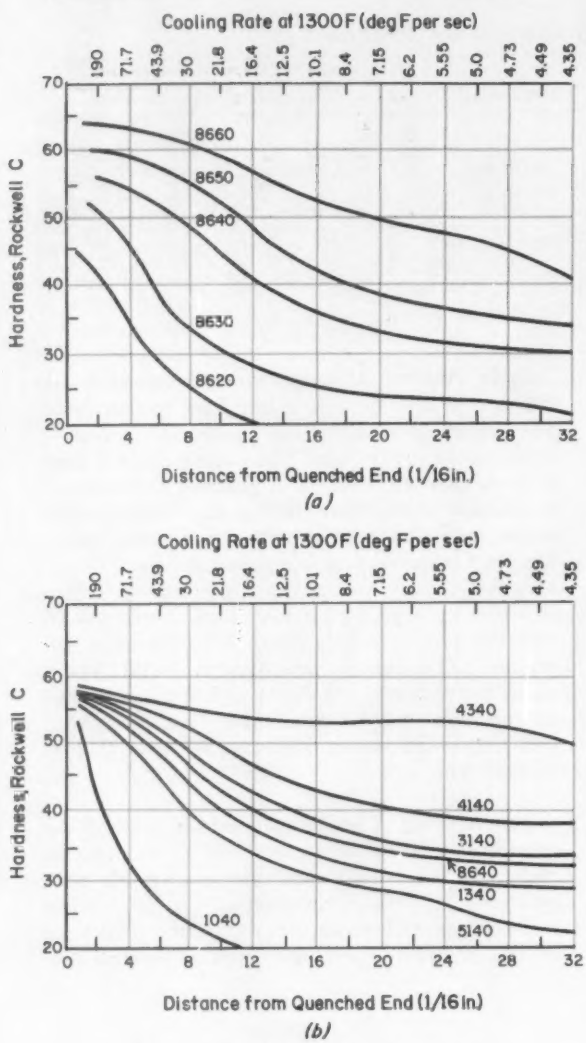


Fig. 5 — Hardenability, *a*, of the 8600 series of alloy steels; *b*, for 0.40 per cent carbon alloy steels.[2]

temper method are: 1. High degree of freedom from distortion and quenching cracks. 2. High level of ductility. 3. Ability to obtain a hardness of about Rockwell C48 without subsequent tempering.

Since the steel must be heated in a conventional furnace to the Ae_3 temperature and then transferred to an isothermal bath operating at 400 to 700 F, the material must have sufficient hardenability so that transformation does not occur during the transfer. It is also essential that the isotherm be maintained above the Ms temperature, since the formation of even a small amount of hard martensite structure is detrimental. The austempering process generally limits the section size of parts because of the relatively low heat-extraction rate of a salt bath. However, mechanical agitation of the bath increases the effectiveness of the quench and permits slightly greater section thicknesses to be treated.

Marquenching: Another heat-treat method that eliminates the temperature differential between the surface and center of a quenched section is martempering or marquenching, Fig. 2c.

Marquenching consists of: 1. A rapid cooling of the steel from above the Ae_3 temperature to just above the Ms point. 2. Holding to permit equalization of temperature throughout the section. 3. Cooling slowly in air to permit transformation to martensite.

Stress level remains high, however, and the steel requires a subsequent tempering treatment. As in austempering, mechanical agitation of the quenching medium permits successful processing of heavier sections, Fig. 3.

Hardening and Tempering: The quench-and-temper heat treatment, Fig. 4, involves a heating to above the Ae_3 temperature and a rapid quenching that delays transformation until the Ms temperature is reached. The end product, martensite, is hard and has high internal stresses and low ductility. To

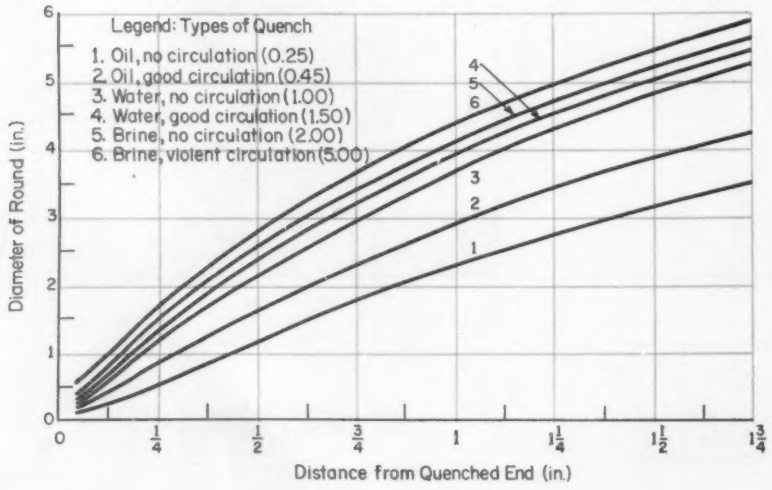

Legend: Types of Quench
1. Oil, no circulation (0.25)
2. Oil, good circulation (0.45)
3. Water, no circulation (1.00)
4. Water, good circulation (1.50)
5. Brine, no circulation (2.00)
6. Brine, violent circulation (5.00)
Diameter of Round (in.)
Distance from Quenched End (in.)

Fig. 6—Relation of distance from the quenched end of a bar to the diameter of a round that has the same hardness at its center, for several types of quench.[3] Numbers in parentheses are measures of quench severity (water quench with no circulation is taken as unity).

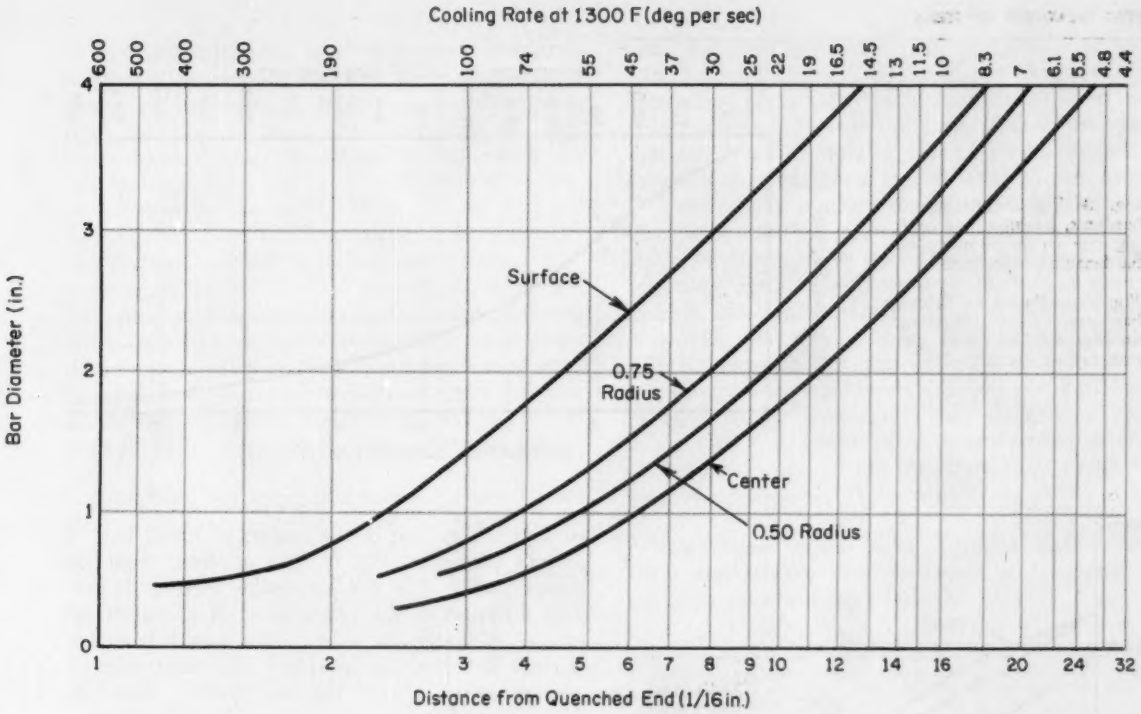


Fig. 7—End-quench hardenability curve for AISI 8640 steel.[3]

obtain a reasonable combination of hardness and ductility and to reduce the stress level, a tempering operation follows the quench. The quench medium can be oil, water, or brine, depending upon the desired cooling rate, the chemical composition of the steel, and the size and shape of section.

Low carbon steels do not respond to this treatment; steels with over 0.25 per cent carbon are shallow-hardened. Shallow-hardening steels normally require a relatively fast cooling rate, produced by a water or brine quench, to obtain an effective hardness.

Since the cooling rate at the surface of a section is more rapid than at the center, for uniformity, the transformation to martensite must be delayed. This can be done by the use of alloys. For example, chromium will delay the transformation so that a less severe quench—oil—can be used to obtain a full martensitic structure at the center of the section. And if the alloy percentage is increased, or if additional alloying elements are used, the same section diameter will quench to martensitic structure with a simple air cool. The obvious advantage of a slower quench is that of minimizing distortion and cracking possibilities.

Hardenability

The inherent characteristic of hardenability is influenced primarily by chemical composition and austenitic grain size. Hardenability differs from hardness. Hardness is the actual end result of hardenability under conditions of a definite cooling rate. Hardenability, on the other hand, is that property that determines the depth and distribution of hardness throughout a section as induced by quenching. Hardenability is a constant; hardness is a variable, since it depends on the cooling rate from the austenitizing temperature.

Earliest evaluations of hardenability were made by quenching a prototype design and measuring hardness versus depth of section. This method was satisfactory to select a steel for a particular service, but the information was restricted to a specific design. A more acceptable method involves the quenching of rounds of different diameters and subsequently determining depths of hardness.

End-Quench Test: Probably the most accepted procedure in evaluating hardenability, the end-quench test, uses the following procedure: 1. A 1-in. diam steel specimen, 4 in. long, is heated to the austenitizing temperature. 2. The specimen is quenched so that a stream of water impinges only on one end of the bar. 3. Two flat surfaces, 0.015 in. deep, are ground longitudinally on the bar, and hardness determinations are read at 1/16-in. intervals from the quenched end.

Results are expressed as curves of hardness versus distance from the quenched end, Fig. 5. A tabular listing of hardness values from Fig. 5*b* is shown in Table 2.

Since the quenching effect is concentrated on the end surface of the test specimen, and since this effect diminishes with distance from the end, points exist along the specimen where the cooling rate

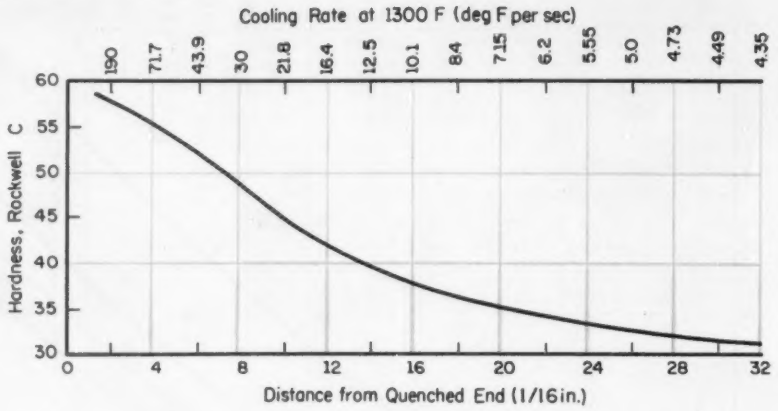
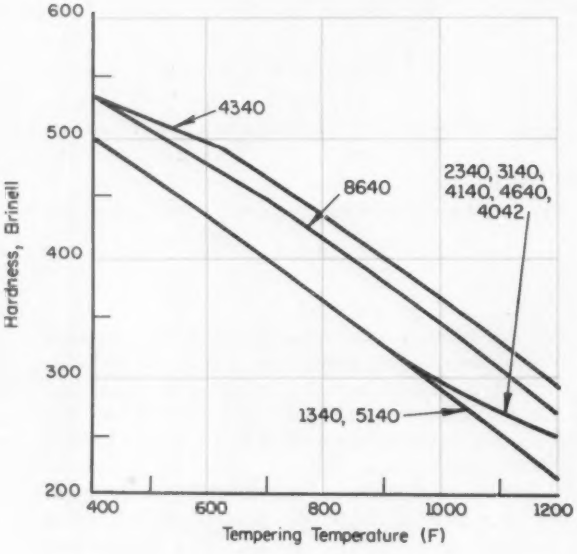


Fig. 8—Right—Relation of hardness, position, and cooling rate on an oil-quenched hardenability specimen.[2]

Fig. 9 — Below — Brinell hardness versus tempering temperature for 0.40 per cent carbon steels.[2]



corresponds to that of the centers of round bars of various diameters, Fig. 6. Also apparent from the curves of Fig. 6 is the permissible increase in section thickness as the effectiveness of a quench increases. Although the severity of a quench is an important factor of hardenability, the most effective quench is not always the best quench, since the factor of part design must be considered in relationship to distortion, quench cracking, and other attendant difficulties.

The end-quench test determines relative hardenability of a steel, and since each position on the test bar can be related to a definite cooling rate (which, in turn, can be related to a bar diameter) it serves as a universal yardstick in relating the potentials of various steels.

Hardenability Bands: The end-quench test is used

Table 3—Effects of Austenitic Grain Size on Steel Properties[4]

Property	Grain Size	
	Coarse	Fine
Machinability*	Better	Inferior
Hardenability	Deeper	Shallower
Plastic forming	Better	Inferior
Rate of carburization	More rapid	Slower
Distortion in heat treatment	More	Less
Impact strength at same hardness	Lower	Higher
Strength (normalized condition)	Higher	Lower
Quenching cracks	More susceptible	Less susceptible
Grinding cracks	More susceptible	Less susceptible
Normality	More normal	Less normal
Internal stresses	More	Less
Soft spots	Less susceptible	More susceptible
Elastic ratio	Lower	Higher
Yield point	Slightly higher	Slightly lower
Ultimate strength	Slightly higher	Slightly lower
Elongation	Less	More
Reduction in area	Less	More

*The fine grain condition may exhibit better machinability than the coarse in plain-carbon open-hearth steels with low carbon content.

Design Example—Hardenability

Problem

A stepped shaft, having diameters of ¾ in., 1 in., and 1¾ in., is to be oil quenched and tempered to a surface hardness of approximately Brinell 300 (about Rockwell C32). Tentative material selection is AISI 8640 alloy steel. Determine the surface hardness at each diameter as quenched, and the necessary tempering temperature.

Solution

1. Find the surface cooling rates for each of the three diameters from Fig. 7. For the diameters of ¾ in., 1 in., and 1¾ in., the cooling rates are 190, 160, and 74 deg F per in. respectively.

2. Determine the as-quenched surface hardness of the three diameters, using Fig. 8. Starting with the small diameter, these values are 57, 56, and 55 Rockwell C, respectively. These hardness values represent the as-quenched condition. The piece must then be tempered to the desired Brinell hardness.

3. Determine the required tempering temperature from the tempering response curve, Fig. 9. For a Brinell hardness of 300 for AISI 8640 steel, the required temperature for final temper is about 1125 F.

to establish minimum and maximum end-quench hardenability curves for many alloy steels. These bands, or hardenability limits, are based on data from hundreds of heats for each grade of steel. Steels that have been investigated in this manner are distinguished from the usual AISI-SAE identification system by the suffix "H" to denote that the material has been produced under a hardenability specification, and that grain size and chemical composition of the steel are of secondary importance. Each steel so designated has a guaranteed minimum and maximum end-quench hardenability value. Some advantages of using H-steels as compared to specifying the same steel by chemistry or grain size are: 1. Greater uniformity of hardness in the finished part. 2. Fewer rejections. 3. Fewer retreatments.

Grain Size: Variations that normally appear, either in mechanical properties, depth of hardness, response to a simple heat treatment, or response to a rate of carburization, frequently cannot be explained on the basis of a chemistry variation. Two heats of steel having identical chemistry can exhibit widely different characteristics after identical treatments because of grain size variations, Table 3.

Grain size is normally expressed as "austenitic grain size." One of the oldest methods to determine austenitic grain size is the McQuaid-Ehn test (ASTM Specification E19), originally developed to determine grain size in the surface layer of pack-carburized low-carbon steel. Other methods that measure this variable include visual comparisons and metallographic examinations of test bars.

Grain size is a temperature-dependent variable. Fine-grain steels are normally produced by the addition of aluminum or vanadium as a grain-growth inhibiting agent. These elements produce a finely divided, not readily soluble, highly refractory oxide or carbide that inhibits grain growth up to about 1700 F. Above 1700, these additives allow a slow rate of grain growth. Steels that are not inhibited in this manner develop relatively large grain size below 1700 F. Although titanium and zirconium are also effective grain-growth inhibitors, these elements have an adverse effect on hardenability.

Next article in this series discusses selection of steels and stresses the importance of matching a heat-treatment with part design.

REFERENCES

1. *U. S. Carilloy Steels*, United States Steel Corp., Pittsburgh, Pa.
2. *Republic Alloy Steels*, Republic Steel Corp., Cleveland, Ohio, 1949.
3. *Modern Steels and Their Properties*, Bethlehem Steel Co., Bethlehem, Pa., 1955.
4. *Cold Finished Bar Steels*, Bliss & Laughlin Inc., Harvey, Ill., 1943.

Tips and Techniques

Fast Scale Drawing

Prints from a Photostat or similar machine capable of reduction or enlargement can be used to reduce layout time. This method is useful in making line drawings of small parts if actual parts are available.

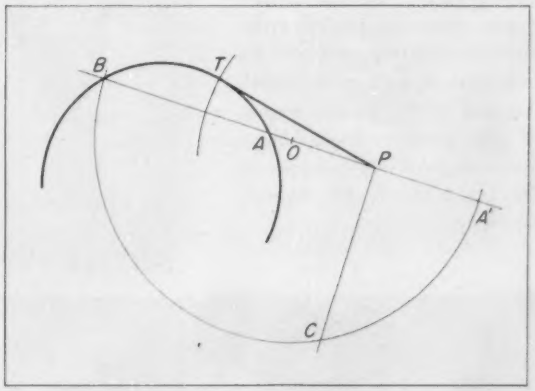
1. Have a Photostat copy of the part made, scaled to the required size.
2. Carbon the back of the copy with a soft pencil.
3. Line up and trace the image on the layout.
4. Darken the traced imprint and add dimension lines as needed.

The result is an accurate line drawing requiring a minimum of time.—OLIVER P. COLE, *Poughkeepsie, N. Y.*

Tangent to an Arc

To draw a tangent from a given point to an arc of a circle whose center is inaccessible:

1. Through the given point P draw any convenient line cutting the arc at A and B, and extend the line to A', making $PA = PA'$.
2. Bisect $A'B$ and swing an arc of radius OA' from the midpoint O. Then drop a perpendicular from P. Intersection of the arc and the perpendicular from P is point C.



3. With radius PC, from P lay off point T on the arc. TP is the required tangent.

When the size of the layout makes it awkward to find PC graphically, it can be found with

$$PC = \sqrt{PA' \times PB}$$

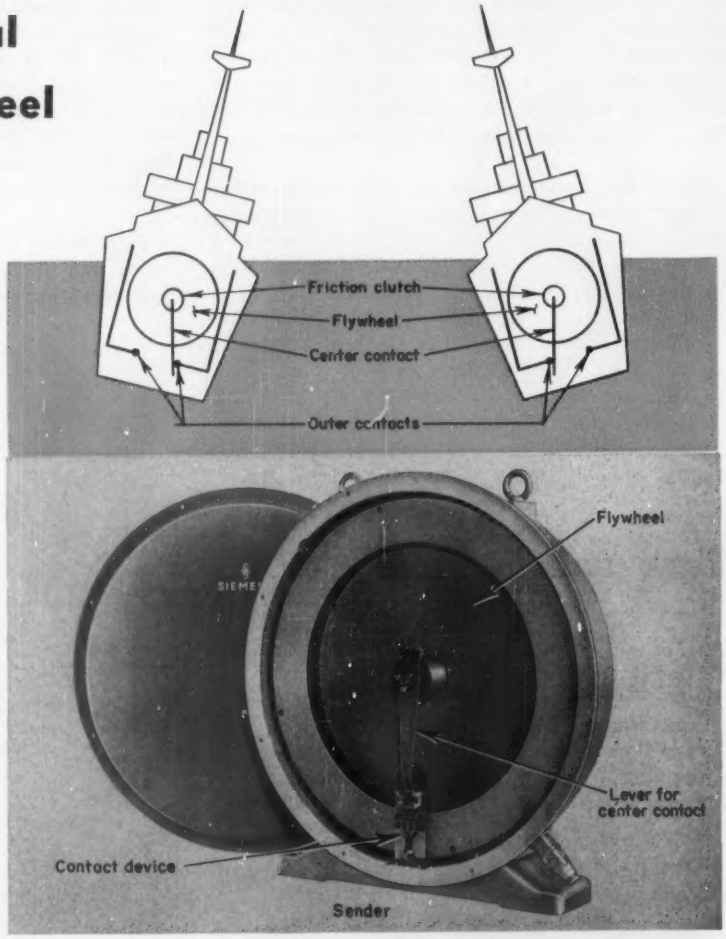
—M. W. LOFTUS, *Chicago, Ill.*

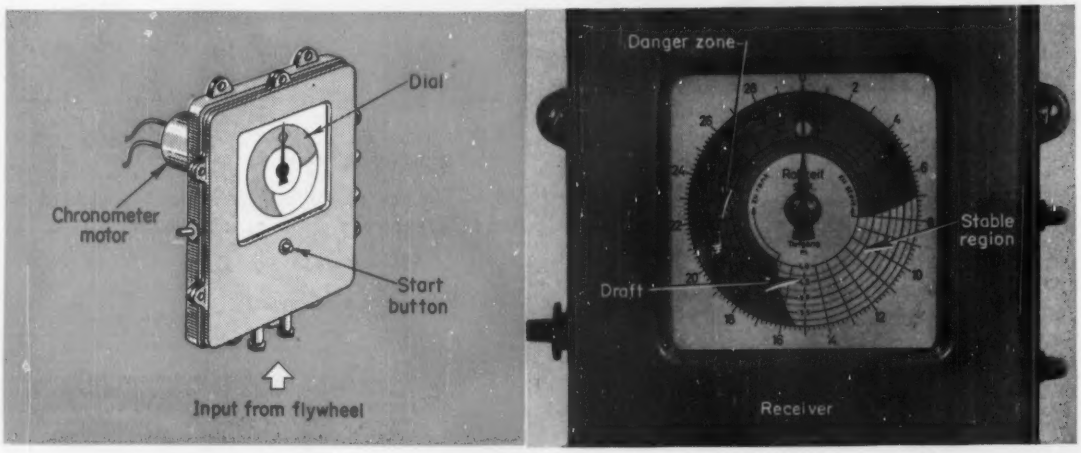
Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

INERTIA of a stationary flywheel is the reference against which ship's roll is measured in a stability meter. The flywheel is coupled to a pointer which forms a pivoted contact between two outer contacts fixed to the ship. As the ship rolls, the outer contacts alternately touch the center contact, thereby closing signal circuits. A friction clutch permits the pointer to override the flywheel on long rolls.

Ship Roll Interval Sensed by Flywheel

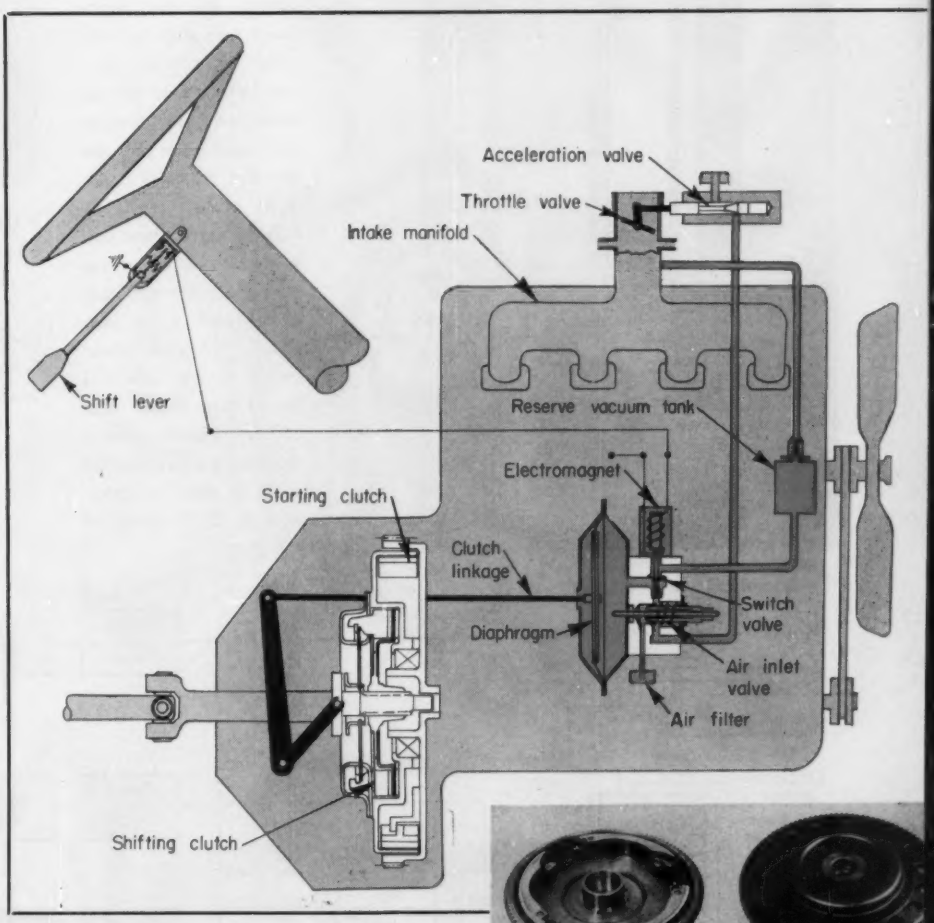
INFORMATION ON SHIP'S STABILITY comes from a chronometer-driven dial pointer. Start button applies voltage to the center contact on the flywheel. First circuit break as the ship reverses roll direction starts the chronometer and a counting train. The chronometer is shut off, after three complete cycles, at the point of reversal. Thus, the pointer is driven around the dial for exactly three roll cycles of the ship. The dial is calibrated in seconds per roll cycle. By combining this input with information on draft of the vessel, the dial chart indicates degree of ship stability or instability. The instrument was designed by Siemens & Halske AG, Munich, Germany.

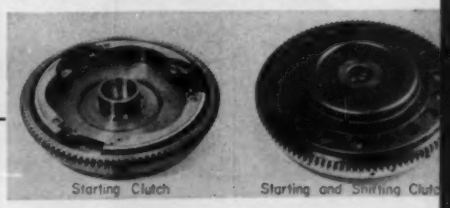




Manifold Vacuum Powers Automatic Clutch Operation

CLUTCH LINKAGE OPERATES on vacuum produced by the intake manifold in an automatic clutch. Purpose of the design is to eliminate foot operation in the stick shifts. It's a refinement offered for small imports like the Volkswagen. Operation of the shift lever closes contacts in valve solenoid circuits. The resulting vacuum moves a diaphragm fastened to the clutch linkage. Completing the shift breaks the circuit and the air inlet valve is released to relieve the vacuum and engage the clutch. Reserve vacuum tank has capacity for four or five shifts with power off. Starting clutch engages centrifugally at 1000 rpm.

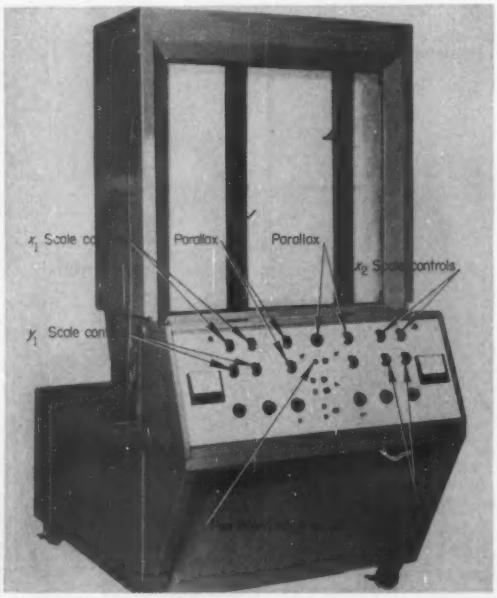


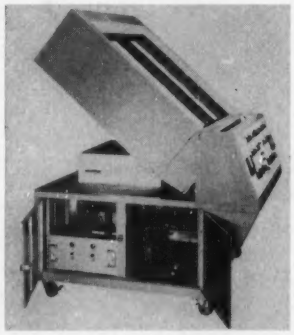


AUTOMATIC CLUTCH WAS SPECIFICALLY DESIGNED for the Volkswagen by August Haeusermann, Stuttgart, Germany. It's the only automatic model available for VW, although it's not sold through the official sales organization.

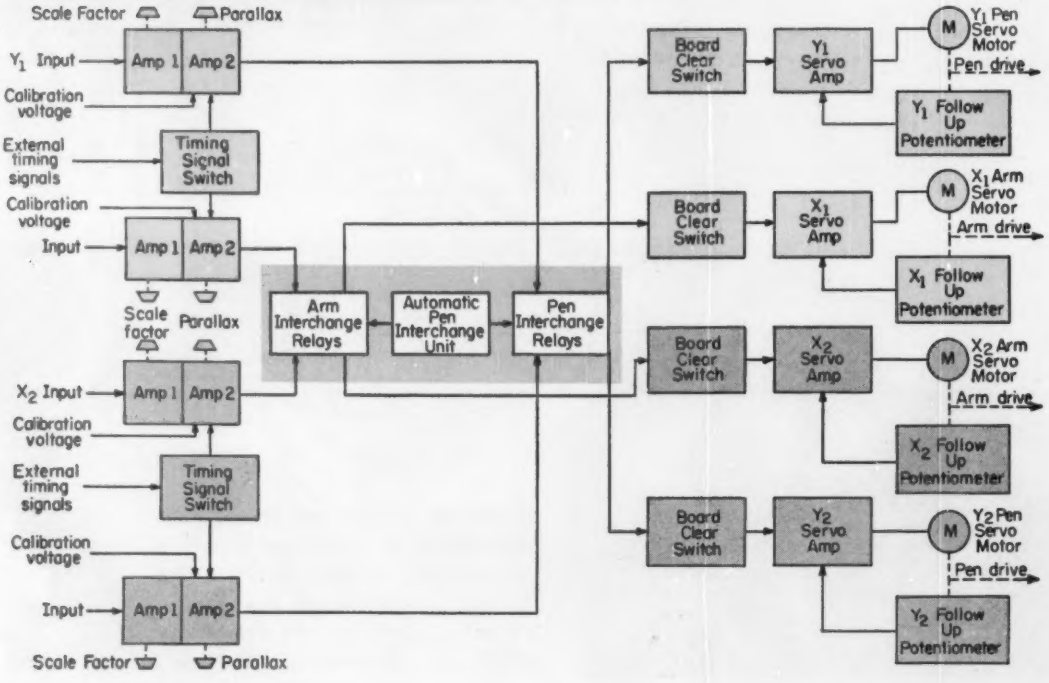
X-Y Recorder Interchanges Functions To Avoid Crossing Arms During Plot

ARMS CAN PLOT two analog functions simultaneously in an x-y recorder. The two arms need never cross, since the functions are automatically interchanged when the arms reach an interference point. It's done with a limit switch on the right-hand arm that is actuated by contact with the left. Arms can be equipped with one or more ball-point pens for plotting in color. On some models the plots can be in different colors and the arms can continue interchanged plots—each in its own color. Board clear switch centers pens and moves arms to the edge of the board without disturbing adjustment of scale or parallax (position of 0, 0 point on the chart).

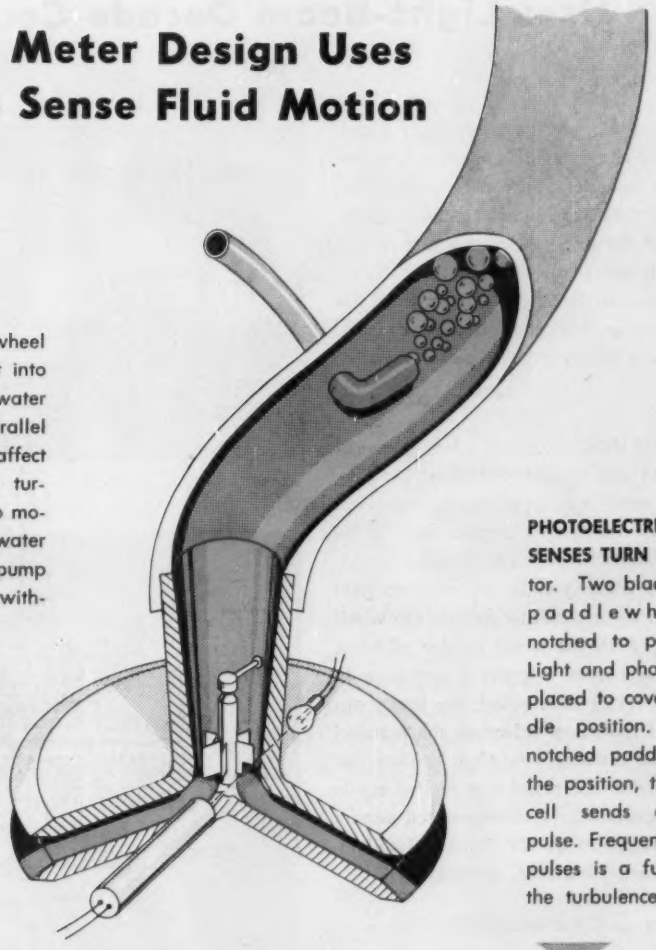




PLOTTING BOARD TILTS to operate in the most advantageous position for the particular installation. The x-y recorder was developed by Computer Systems Inc., Monmouth Junction, N. J., for use on missile ranging installations.



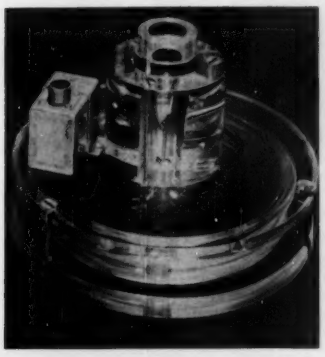
Turbulence Meter Design Uses Paddlewheel To Sense Fluid Motion

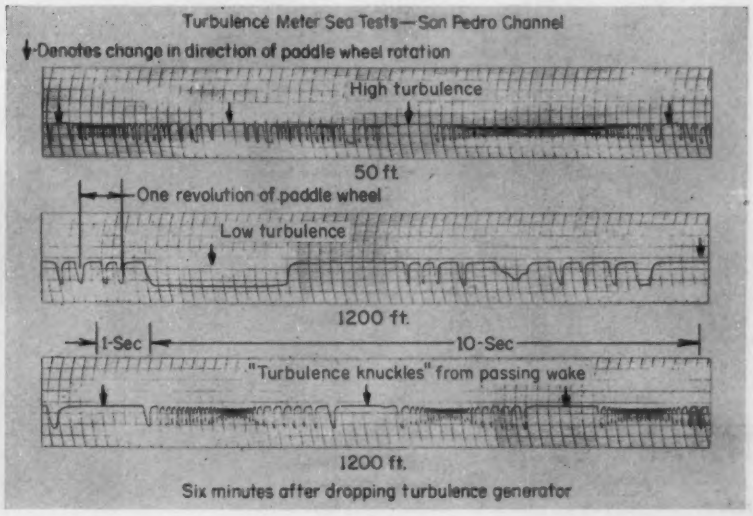


ROTOR COMPOSED of a paddle wheel mounted on needle bearings is put into motion by eddy currents in the water drawn past it. Water moving parallel to the shaft of the rotor does not affect it. Eddy currents are caused by turbulence in the surrounding water, so motion of the rotor is a measure of water turbulence. Compressed-gas bubble pump draws water through the instrument without introducing turbulence.

PHOTOELECTRIC CELL SENSES TURN of the rotor. Two blades of the paddlewheel are notched to pass light. Light and photocell are placed to cover a paddle position. As the notched paddle passes the position, the photocell sends a signal pulse. Frequency of the pulses is a function of the turbulence.

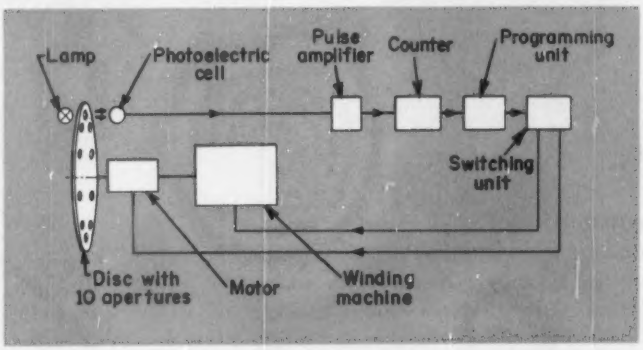
TURBULENCE METER WAS DEVELOPED by the Anti-Submarine Warfare Div., Aerojet-General Corp., Azusa, Calif.



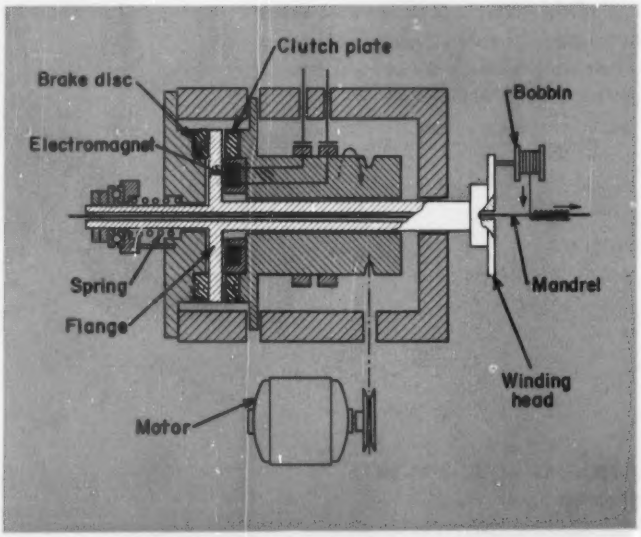


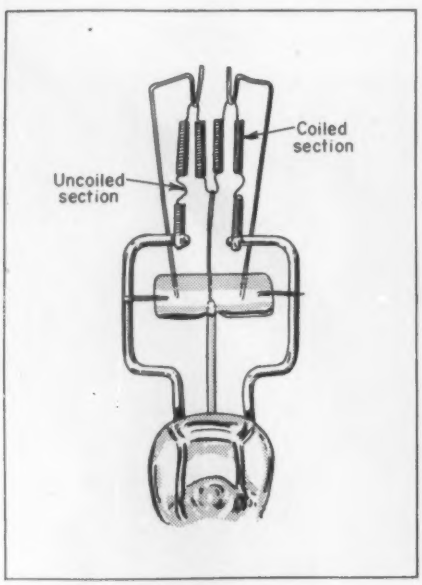
Intermittent Coil Winder Uses Light-Beam Decade Counter

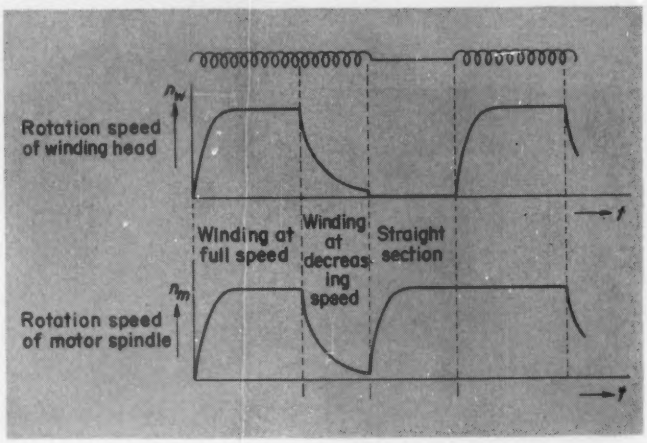
ROTATING DISC with ten equally spaced perforations near its edge controls angular position of an intermittent coil winder. The ten perforations correspond to ten angular positions of the disc. A lamp and a photoelectric cell are placed astride the path of the revolving perforations. Pulses from the cell operate a four-stage decade counter, which counts down from a preset number.



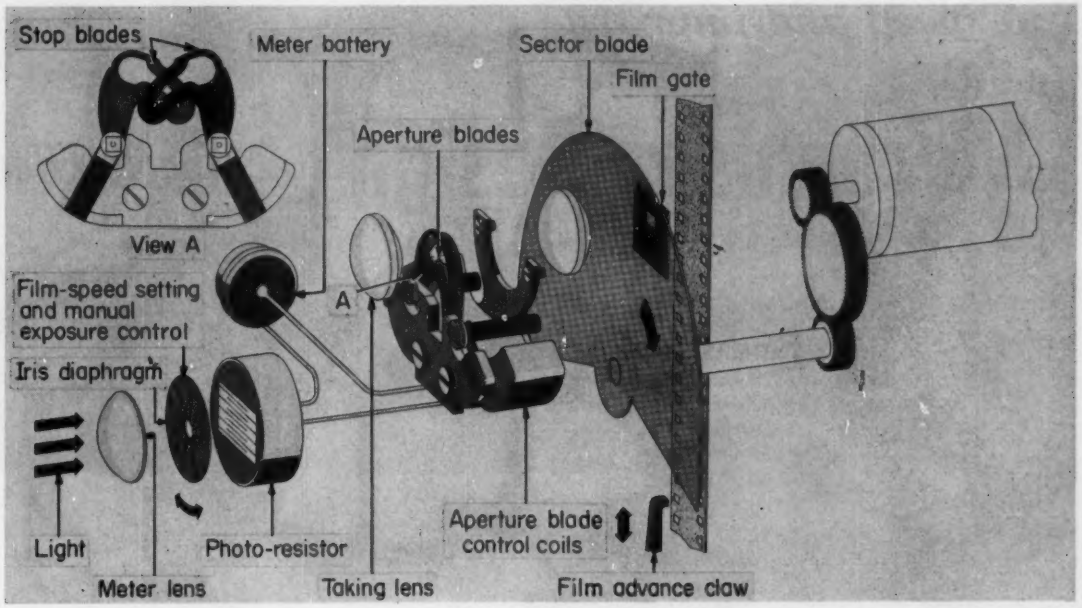
COUNTER IS USED to control winding operation of an intermittent coil winder. Purpose is to make a series of alternating coiled and straight sections of tungsten wire to be used as filaments in large tungsten lamps. During the winding cycle, an electromagnet engages a plate clutch to operate the winding head. After the preset number of turns, the decade counter triggers a sequence in which the clutch is released, the brake applied, and the motor advances the mandrel a measured distance through a linkage (not shown). Later the mandrel is melted out in another operation. Intermittent coil winder is a development of NV Philips' Gloeilampenfabrieken, Eindhoven, Holland.



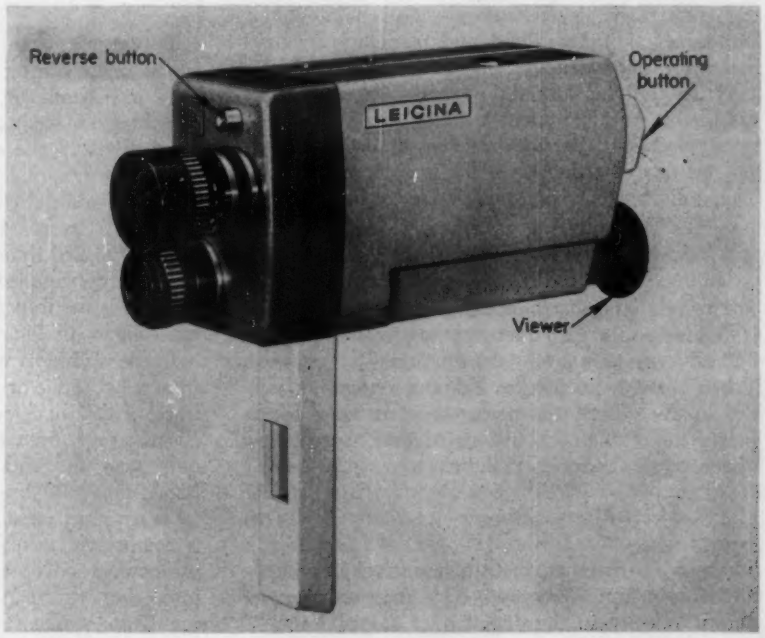



Rotation speed of winding head
Winding at full speed
Winding at decreasing speed
Straight section
Rotation speed of motor spindle

Resistor Replaces Photocell to Operate Movie-Camera Aperture



MOVIE CAMERA USES a photosensitive resistor instead of the usual photoelectric cell to control the diaphragm opening for its lense. Additional power available from the battery in this system makes aperture control very sensitive. Effects of friction or inertia are minimized. Adjustment for speed of various films used in the camera is made with an iris diaphragm that controls the amount of light reaching the resistor. Battery power, controlled by the photoresistor, furnishes torque to rotate two crossing "stop" blades with tapered slots. The slots form a variable aperture depending on what part of the slots crosses the image path.



PRESSING THE REVERSE BUTTON short-circuits the cell, and if the meter battery is in good condition, causes the aperture indicator to read f-16. This is the suggested method for checking the condition of the battery. Movie camera, called Leicina, is a design of Ernst Leitz GmbH, Wetzlar, Germany.

How to use four basic concepts to speed and improve

Mechanism Design

1. Constraint
2. Toggle Effect
3. Rotation
4. Inversion

THOMAS P. GOODMAN
Kinematics Engineer
General Engineering Lab.
General Electric Co.
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MECHANISMS are used not merely to transmit motion from an input member to an output member but also to transform the available input power (force times velocity) into the force or velocity level most suitable to overcoming the output load. When the transformation from input to output takes place at constant rate, gear pairs, chains and sprockets, differentials, and planetary arrangements are happy choices of types of mechanism.

When the transformation takes place at variable rates, the variable-pitch wedging action of cam mechanisms and the toggle action of linkages often can be used to advantage. For the most part, this article discusses mechanisms of the toggle type.

Mechanical Advantage

The mechanical advantage (m) of a mechanism is defined as the instantaneous ratio of force output, F_o, to force input, F_i, when friction is neglected. When there is no friction loss and no energy storage in the system, the power input is equal to the power output at each instant of time, by the law of conservation of energy; therefore

$$m = \frac{F_o}{F_i} = \frac{{}_eV_i}{{}_eV_o} \qquad (5)$$

where ${}_eV_i$ is the component of input velocity in the direction of input force and ${}_eV_o$ is the component of output velocity in the direction of output force.

The equivalence of these two expressions for mechanical advantage is of great importance because the force ratio is significant in some problems while the velocity ratio is significant in others. Also, in some problems the force ratio is the easier to compute, and in others the velocity ratio is the easier to compute.

To use a constant input force to overcome a load which varies during a machine stroke, a mechanism with a nonuniform mechanical advantage is preferred. An elementary example of such a requirement arises in the design of a mechanism to compress a linear spring, Fig. 10.

With an initial compression of 50 lb and a gradient of 20 lb per in., the force increases linearly from 50 to 250 lb as the spring is compressed 10 in. The energy supplied to the spring during this compression is the trapezoidal area under the force curve, i.e., 1500 in.-lb, Fig. 10.

If the spring is compressed by a direct force, as from a hydraulic or pneumatic cylinder, an available force of 250 lb is required at every position in the 10-in. stroke, even though this force can be utilized only near the end of compression. On the other hand, the 1500 in.-lb can be stored in the spring by a constant force of less than 250 lb if the spring is compressed through a mechanism with a variable mechanical advantage. Thus in this example, the force may theoretically be reduced to 150 lb over the 10-in. stroke. The mechanical advantage of the

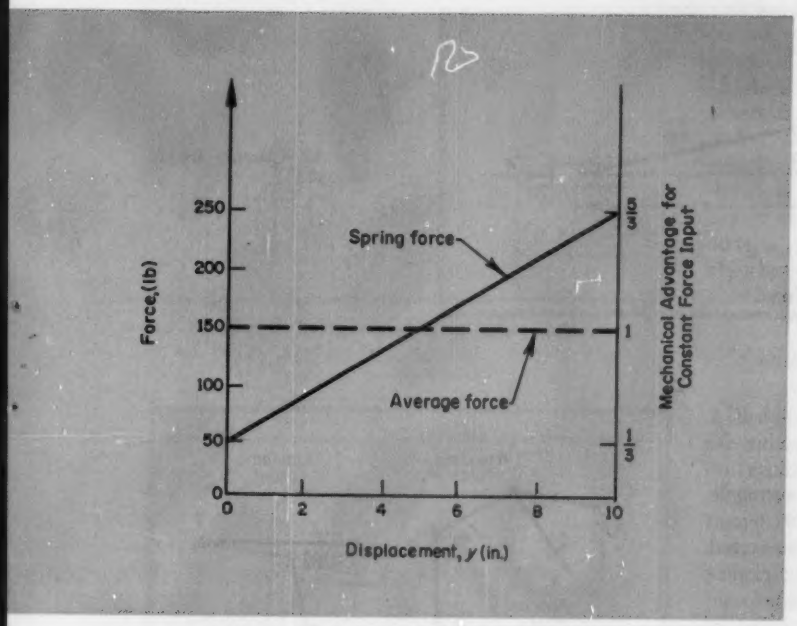

Fig. 10—Force and displacement to compress a linear spring.

mechanism increases linearly from 1/3 to 5/3.

Friction losses in the mechanism will increase the required force to something above 150 lb, but the introduction of the variable mechanical advantage still results in a substantial reduction in input force. Particularly in aircraft applications, where sizes and weights of actuators must be kept to a minimum, such a reduction can be of great importance.

Cams With Variable Mechanical Advantage

The design of a cam mechanism for variable mechanical advantage is straightforward. Consider a translation cam with x as the input displacement and y as the output displacement.

$$m = \frac{\text{Input velocity}}{\text{Output velocity}}$$

so that

$$m = \frac{\dfrac{dx}{dt}}{\dfrac{dy}{dt}} = \frac{dx}{dy} \qquad (6)$$

Hence, a curve of $x = f(y)$ can be obtained simply by integrating the m curve of Fig. 10:

$$x = \int m\, dy \qquad (7)$$

Then, the required cam schedule of $y = f(x)$ is obtained merely by interchanging axes.

Once the desired output-vs-input schedule has been determined, the design of the cam can be carried out in the traditional manner.[1] The cam may be regarded as a variable-pitch wedge. The lower the mechanical advantage which is to be mechanized, the larger the cam base radius must be to keep the cam pressure angle within reasonable limits.

Toggle Linkages

The design of a link mechanism for a desired mechanical advantage is also based on the output-vs-input-displacement schedule. The quantitative design of link mechanisms to match prescribed curves will be discussed later and in succeeding articles. At the moment it is helpful to get a qualitative idea of the variation in mechanical advantage that is achievable from a mechanism of a given type. In such a qualitative approach, the variable mechanical advantage of a linkage can best be understood in terms of toggle action in the links.[2]

A toggle linkage may be defined as a mechanical linkage containing two links, connected by a pivot, which tend to line up in a straight line at one point in their motion. The simplest type of toggle linkage is illustrated by Fig. 11. In this linkage, a force is applied at A to overcome a force at B. The mechanical advantage is $(1/2)\tan\alpha$, which is equal to the

[1]References are tabulated at end of article.

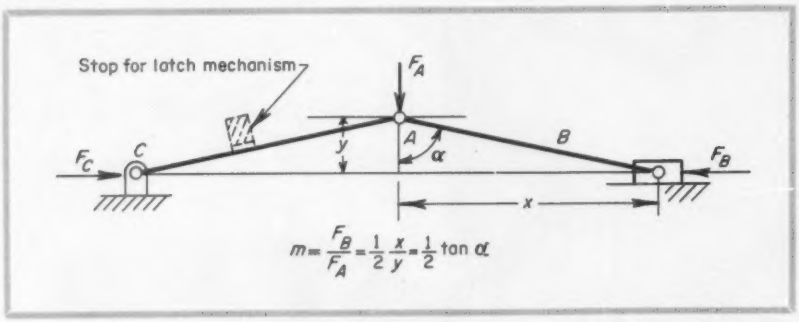

Fig. 11 — Simple toggle linkage.

ratio of the vertical component of the velocity of A to the velocity of B. As the angle α approaches 90 deg, the mechanical advantage becomes infinite.

When α approaches 90 deg, making the two toggle links form a straight line, the links are said to "come into toggle." The effect of friction makes the actual ratio of forces something less than infinity; nevertheless, the actual ratio of forces at the toggle position is still much greater than at any other point in the stroke.

In machines like rock crushers and punch presses where this linkage is used, the infinite mechanical advantage is of great value in overcoming a large force. However, this linkage is also used as the connecting rod and crank of an engine, where F_B is the driving force and F_A is the resisting force. In an engine, if the angle α becomes 90 deg, the linkage is locked in a dead-center position, in which no horizontal force at B, however large, can cause motion at A. This property is of great value in latch mechanisms. Thus, a toggle linkage is merely a dead-center linkage viewed from the opposite end.

The simple toggle linkage shown in Fig. 11 has many variations, two of which are illustrated in Fig. 12. As shown in Fig. 12*a*, the forces may be applied through other links and need not be perpendicular to each other; and a toggle link may be attached to another link, rather than to a fixed point or slider. As shown in Fig. 12*b*, the two toggle links may come into toggle by lining up on top of each other rather than as the extension of each other; and the resisting force is often a spring force. All these variations have the essential property of the toggle linkage—the infinite mechanical advantage that occurs when the toggle links come into toggle.

A familiar application of the toggle mechanism to overcome a large force at one point in a machine stroke is the punch-press mechanism, Fig. 13. The flywheel rotates to move the punch up and down. Near the lower end of the punch stroke, a large force is needed to pierce the workpiece; however, very little force is needed on the punch during the remainder of the stroke. The crank and connecting rod come into toggle at the lower end of the punch stroke, giving a large mechanical advantage in the portion of the stroke when it is most needed. During most of the remainder of the stroke, the mechanical advantage remains low.

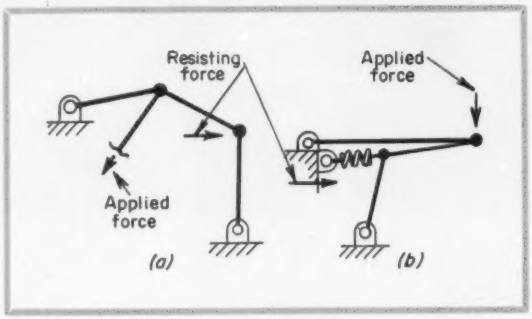

Fig. 12—Variations of toggle linkage.

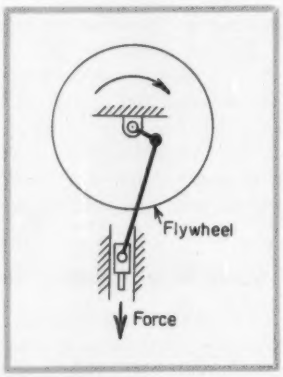

Fig. 13—Toggle linkage applied in punch press.

Another example of the use of a toggle mechanism to overcome a large force at one point in a machine stroke is a stone crusher, Fig. 14. This mechanism uses two toggle linkages in series to obtain a high mechanical advantage. When the vertical link b reaches the top of its stroke, it comes into toggle with the driving crank a; at the same time, link c comes into toggle with link d. This multiplication of toggle effects results in a very large crushing force on the stone when the linkage is in the toggle position.

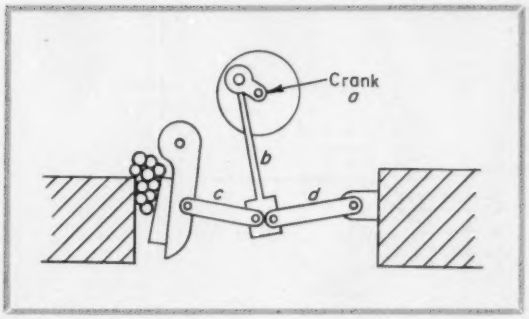

Fig. 14—Toggle linkages applied in stone crusher.

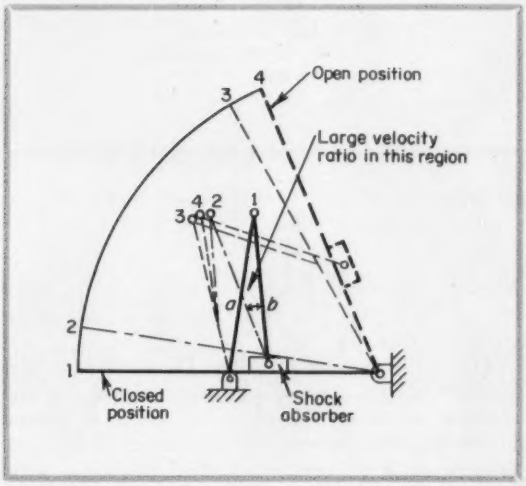

Fig. 15—Toggle linkage applied in door-check mechanism.

A toggle linkage can also be used to obtain a high output velocity at one point in a stroke. This application is illustrated by the door-check linkage, Fig. 15. As the door swings closed, the connecting link *a* comes into toggle with the shock-absorber arm *b*, giving it a large angular velocity. The angular velocity ratio between the shock-absorber arm and the door itself is much greater when the door is nearly closed (positions 1 and 2) than when the door is open (positions 3 and 4). Thus the shock absorber has much greater effect in retarding the door near the closed position.

Linkages to Approach Toggle Position

In designing a linkage having a variable mechanical advantage which does not actually reach infinity, a qualitative idea of where to go in the design may often be obtained by observing the direction in which links tend to approach a toggle position, even if they do not actually get there. This principle can be seen easily in four-bar linkages, Fig. 16, and in bell-crank linkages, Fig. 17. It can be applied also quite generally to more complex linkages.

Fig. 16*a* with parallel cranks has a uniform mechanical advantage of one, since cranks *a* and *c* both come into toggle with coupler *b* at the same time. If the center distance between the fixed pivots is increased, Fig. 16*b*, links *b* and *c* approach a toggle position at the upper end of the stroke, and links *a* and *c* approach a toggle position at the lower end of the stroke.

An increase in the coupler length, Fig. 16c, causes the opposite effect: Links *a* and *b* approach a toggle position at the upper end of the stroke, while links

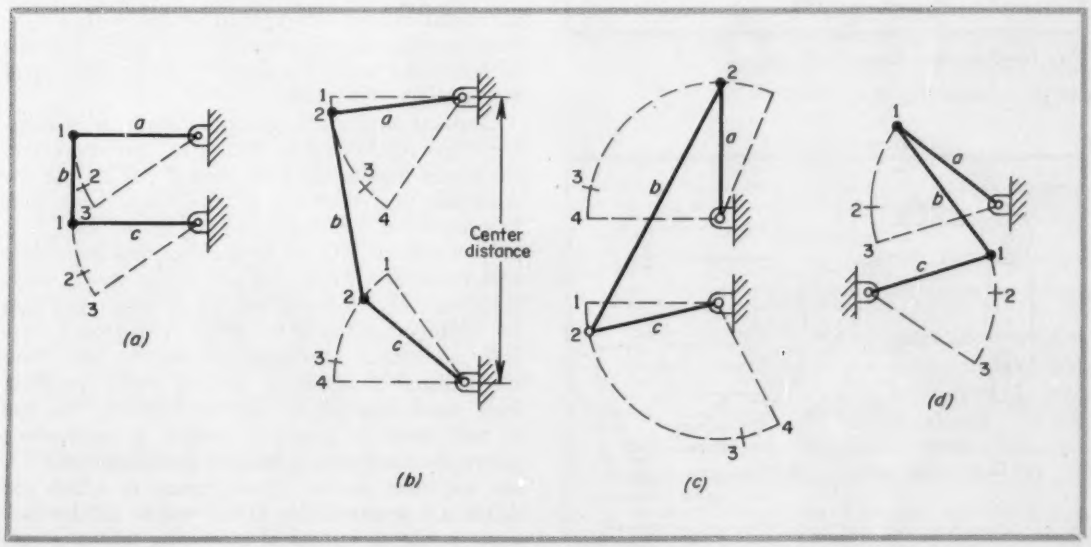

Fig. 16—Toggle effects in four-bar linkages.

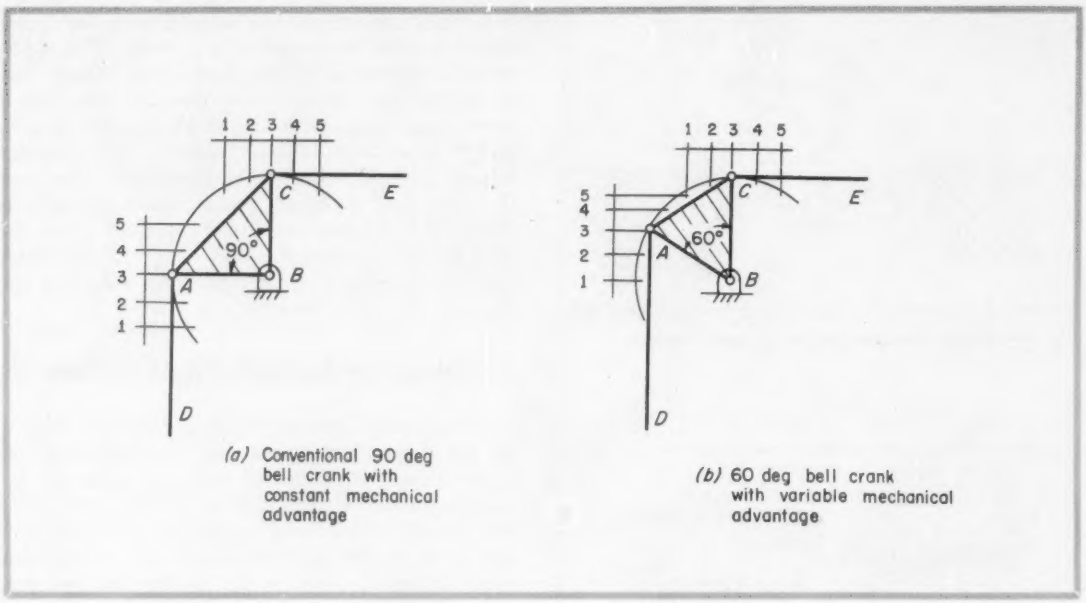

Fig. 17—Bell cranks with mechanical advantage.

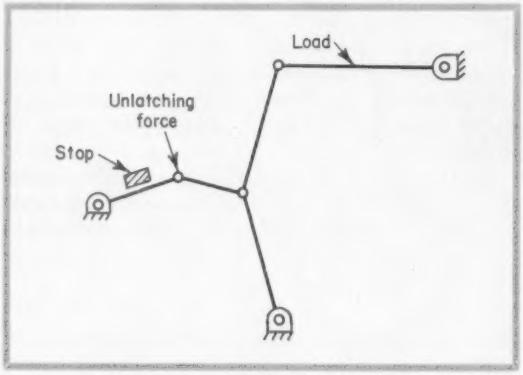

Fig. 18—Two-stage toggle latch.

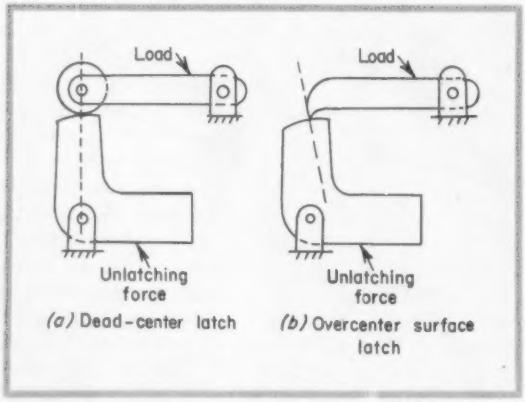

Fig. 19—Latches based on cam action.

b and *c* approach a toggle position at the lower end of the stroke. The same effect is present in the crossed linkage, Fig. 16*d*.

The bell-crank linkage, Fig. 17, provides a particularly simple way of obtaining a variable mechanical advantage. Often a bell crank is present in a mechanism anyway, and then it can be exploited to produce a variable mechanical advantage with no increase in the complexity of the mechanism. This may make it possible to reduce greatly the input force required to perform a task such as compressing a spring or closing a valve. Fig. 17*a* shows a conventional bell crank which is used to change horizontal motion into vertical motion with a constant mechanical advantage, so that equal intervals of horizontal travel (positions 1 to 5) give equal intervals of vertical travel.

Constant mechanical advantage results from keeping angle *ABC* equal to 90 deg so that crank arm *AB* comes into toggle with vertical rod *AD* at the same time that crank arm *BC* comes into toggle with horizontal rod *CE*. By decreasing angle *ABC*, Fig. 17*b*, vertical rod *AD* can be made to come into toggle with crank arm *AB* at one end of the stroke, while horizontal rod *CE* comes into toggle with crank arm *BC* at the other end of the stroke. This gives a variable mechanical advantage, as may be seen from the unequal intervals of vertical travel resulting from equal intervals of horizontal travel. The use of bell cranks is generally limited to applications where the small lateral motions of rods *AD* and *CE* are not objectionable. Arrangements in which rod *AD* is not perpendicular to *CE* and in which crank angle is obtuse instead of acute also influence mechanical advantage and should not be overlooked.

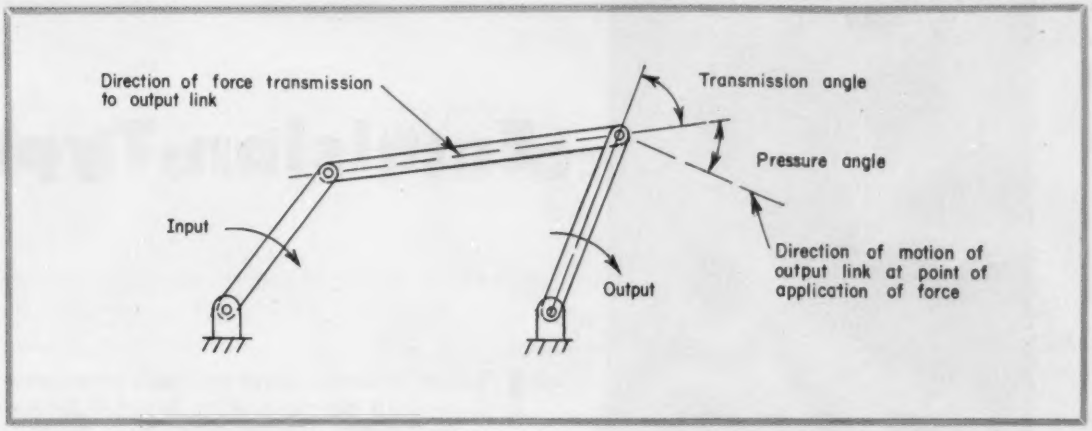
Direction of force transmission to output link
Transmission angle
Pressure angle
Input
Direction of motion of output link at point of application of force
Output

Fig. 20—Transmission angle for a link mechanism.

Latch Mechanisms

The simple toggle linkage may be converted into a latch mechanism[3] by adding a stop as shown in dotted lines, Fig. 11. The latch load is F_B and F_A is the unlatching force. With no friction, the latch will trip whenever tripping force F_A exceeds 2 F_B/ tan α. Once the latch has started to trip, force F_A required to overcome F_B decreases to zero as angle α increases to 90 deg, and then becomes negative (i.e., F_B drives the toggle links) past this point.

This snap action which is produced by driving the toggle links over center (i.e., through the toggle position) gives this latch mechanism its name of "snap-action latch" or "overcenter toggle latch." When friction is taken into consideration, initial tripping force F_A is increased and angle α at which F_A drops to zero becomes greater than 90 deg; the effects of friction can be readily evaluated[4,5] from a friction-circle analysis.

Toggle linkages can also be used to reduce forces in a two-stage latch. Such an application is shown in Fig. 18.

The toggle latch may be compared with two other types of latches, Fig. 19, which are based on cam action: The dead-center latch, which is essentially a cam and follower with the cam having zero pressure angle, and the overcenter surface latch, which is a cam and follower with the cam having a small negative pressure angle.[3] The dead-center latch has the advantage of having a tripping force which is insensitive to the position of the links but has no snap action. The only tripping force required is the force needed to overcome friction.

Transmission Angle

Four-bar linkages such as those shown in Fig. 16 have locking conditions when the output crank c comes into toggle with the connecting rod b. To establish a criterion for avoiding this condition, the transmission angle[6,7,8,9] is defined as the angle between the direction of force transmission to the output link and the normal to the direction of motion of the output link at the point of application of the force, Fig. 20. From this definition it may be seen that the transmission angle is the complement of the pressure angle as defined for cam followers.

As is customary in discussions of transmission angle, Fig. 20 does not include the effect of inertia forces. In high-speed applications, however, they should be included when determining the direction of force transmission to the output link.

The most favorable transmission angle is 90 deg, and transmission angles that cause locking, even with no friction, are zero and 180 deg. When friction is present, locking occurs as the transmission angle approaches zero or 180 deg. The conditions for locking can be determined by a friction-circle analysis. For smooth operation, it is usually desirable to keep the transmission angle between 40 and 140 deg.

ACKNOWLEDGMENT

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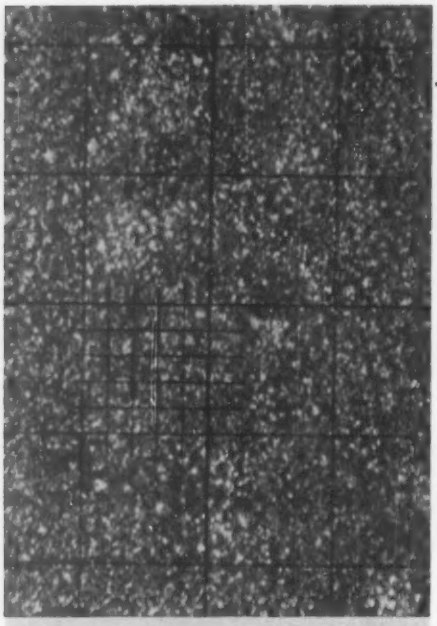

Fig. 1—Photomicrograph of a typical water-in-oil emulsion. Each of the small squares represents 5 microns (0.0002 in.).

Emulsions Compared to Conventional Oils

- **Advantages of Emulsion**
  1. Fire resistance
  2. Higher viscosity index
  3. Higher specific heat
  4. Distinctive appearance — aids in leak location and fluid identification
  5. Detergent action—aids in maintaining system cleanliness
  6. Low cost
- **Properties Requiring Special Design Considerations**
  1. Non-Newtonian viscosity
  2. Limited temperature range
  3. Holds debris in suspension
  4. Affects seals and filters that are not water-resistant
- **Properties Similar to Conventional Oils**
  1. Compatible with normal seals, gaskets, and hoses
  2. Compatible with paints and pipe dopes
  3. Kinetic and static coefficient of friction
  4. Resistance to foaming
  5. Corrosion protection

Emulsion-Type

USE of hydraulic power near high temperature materials presents a safety hazard if the hydraulic fluid is inflammable. Even the best-designed system will leak occasionally. Thus a fire-resistant hydraulic fluid helps prevent a minor mishap from becoming a major tragedy.

Fire resistance plus low cost combine with other desirable characteristics to make emulsion-type fluids attractive for many applications.

Normally, emulsion-type hydraulic fluids, or water-in-oil emulsions, consist of minute particles of water suspended in a continuous phase of a conventional petroleum oil. (The water-in-oil emulsions should not be confused with oil-in-water emulsions, or conventional soluble oils which have water as the continuous phase. Generally, soluble oils are not acceptable in conventional hydraulic equipment because of their lower viscosity and limited lubricity.)

Fig. 1 shows a typical fluid containing 37 per cent water as particles ranging from ½ to 3 microns in diameter. These water particles are generally smaller than the clearances through which the oil flows. However, they also are able to flow and deform to match the conditions of individual hydraulic components. The water particles are tightly enclosed in an oil film which prevents their direct contact with surfaces. Hence, the water has no effect except when high temperature or vacuum causes its volatile release from the fluid. Since the water particles are surrounded with a relatively low volatility oil film, water loss at normal operating temperatures is held to a minimum. Many industrial systems have operated for 1 to 2 years without significant loss of water from the fluid.

When an emulsion-type fluid is exposed to the high temperatures of molten metals, open flame, or electrical discharge, the rapidly released steam blanket surrounds and cools the area of contact, and displaces air from the immediate vicinity. Strong air currents will dissipate the steam, leaving a portion of the oil phase. The oil may ignite and burn with a low, luminous flame in the immediate vicinity of the source of high temperature, but this flame will not trail away from this area nor will the nearby fluid support its own combustion.

Properties of a typical water-in-oil emulsion are shown in Tables 1 and 2. Obviously, the addition of water to a petroleum oil affects many of its signifi-

Hydraulic Fluids

Presently available hydraulic fluids can be divided into five major categories. The most widely used is the petroleum type. However, it is not fire-resistant. For applications requiring a fire-resistant fluid, one of the other major types — aqueous, emulsion, ester, or chlorinated hydrocarbon—must be used. Each of the five types has its unique advantages and disadvantages which must be considered when a fluid is selected for a specific application.

This article discusses the emulsion-type fluid. Future articles will be devoted to each of the other four types of fluids.

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cant characteristics. Some of these are advantageous; some require special design consideration, while others are directly comparable to conventional petroleum hydraulic fluid.

Viscosity Characteristics: Water-in-oil emulsions will meet the normal operating viscosity requirements of system components. However, viscosity does change under shear, Fig. 2. This non-Newtonian characteristic results from a deformation of the water particles, and is complete at shear rates above 10,000 sec^{-1}. Viscosity is stable at the higher shear rates normally produced in high-pressure systems.

The effect of temperature on viscosity at high and low shear rates is shown in Fig. 3. A conventional hydraulic oil of the same viscosity range is shown for comparison. The water-in-oil emulsion has a typical viscosity index of 145, indicating a relatively small change in viscosity over the operating temperature range.

The viscosity of the emulsion decreases with a decrease in water content, Fig. 4. The rate of viscosity decrease with water loss is relatively small. A tolerance of ±5 per cent in water content is acceptable for operating systems. Although the evaporative loss of water is very low at normal operating temperatures, a periodic measurement should be made.

Operating Temperatures and Pressures: Industrial hydraulic equipment is normally designed to standards which specify fluid operating temperatures of 100 F to 130 F. Emulsions should be limited to a peak temperature of 150 F because of the increased evaporative loss of water at higher temperatures. Minimum operating temperatures are based on the pumpability of the fluid in the equipment. For example, a general limit of 4000 SSU is suggested for elevated vane pumps. As shown in Fig. 3, this viscosity is reached at about the same temperature for both the emulsion and the oil. However, because of the flow resistance of the emulsion at low shear rates, a higher starting temperature is desirable.

The high specific heat and good surface wetting of the emulsion improves heat transfer from the system. Tests indicate that water requirements are re-

Table 1—Properties of a Typical Emulsion

Specific gravity at 60/60	0.92
Weight (lb per gal)	7.64
Specific heat at 70 F (Btu/lb/deg F)	0.67
at 100 F	0.68
at 140 F	0.69
Coefficient of thermal expansion at 60 F (in./in./deg F)	0.0003
Water (per cent by volume)	37
(per cent by weight)	40

duced for coolers, or that lower equilibrium temperatures occur in air-cooled systems.

Emulsions are not damaged by high pressures. Rather, they are made more stable by the higher rates of shear in high-pressure equipment. Currently, emulsions are used in hydraulic systems to 20,000 psi with completely satisfactory results. However, emulsions should not be used in equipment operated at pressures above pump manufacturers' recommendations.

Suction Lines and Strainers: The lower shear rates produced in well-designed suction lines and strainers indicate that they will carry the emulsions at their higher viscosity level. The common arrangement of 100 mesh strainers having a rated capacity of 1½ to 2 times that of the system pumps may be limiting with fire-resistant fluids. Strainers of 40 to 60 mesh, having a rated capacity of approximately 4 times pump capacity, will eliminate pump cavitation at low starting temperatures and permit desirable pump suction. Magnetic suction strainers show excellent performance when used with the emulsion-type fluids.

Line sizes which provide the normal 3 to 6 fps flow rates are satisfactory. However, the increased viscosity and density of these fluids will cause a slight increase in pressure drop in the suction lines.

Filtration: Adequate filtration is very necessary in all precision hydraulic systems. Although suction strainers will retain fibrous materials and large particles of debris, these strainers cannot be relied upon to trap solid particles of 5 to 150 microns diameter. These particle sizes are comparable to the clearances in the hydraulic components.

Thus, the particles may be trapped, causing sticking and scoring of critical elements. Because of the greater density, higher viscosity, and two phase composition of these emulsions, they tend to suspend and recirculate this size particle.

A majority of the 5 to 150 micron particles in closed systems are metallic: Machining debris left during the assembly of the equipment; wear particles from system pumps, hydraulic motors, valves, and cylinders; and debris carelessly added during maintenance. Magnetic filters, either as suction strainers, pressure side filters, or simply magnets placed in the machine reservoir, are the most practical means of removing this debris. These units must be accessible for periodic cleaning.

A portion of the recirculated debris consists of nonmagnetic metals and other solids. Pressure side bypass filters or portable pressure filters periodically attached to each machine provide satisfactory means of removing these materials. Normally, emulsions are not compatible with conventional adsorptive or absorptive filter elements because of the extraction of the additives and the effect of water on these units. Metallic filter elements such as the sintered metals, fine-wire screens, edgeplate, and metallic ribbon filters can be used satisfactorily.

Wear Resistance: System wear is influenced by many factors: System cleanliness, operating conditions, and the characteristics of the fluid. These multiple variables make it impossible to predict the wear that can be expected in any new system. Field experience with water-in-oil emulsions indicate equipment life varies from 50 to 100 per cent of that experienced with a regular oil. The difference depends upon the severity of the operation. For example, suspension and recirculation of abrasive debris is a major factor in pump wear with the emulsion. The installation of proper filtration systems will reduce wear rates to an acceptable level.

The ability of a fluid to provide satisfactory lubrication of clean contacting surfaces can be measured by the coefficients of friction under various operating conditions. In the range of hydrodynamic lubrication, friction is largely a function of viscosity which, in turn, is influenced by temperature and shear rate. Under normal conditions, frictional resistance of the emulsion is comparable to that of a petroleum oil of the same viscosity.

Under conditions of boundary lubrication, frictional resistance is the net result of a complex interaction between the lubricant and the metal surfaces. Coefficients of friction, both kinetic and static, have been determined for several emulsions and a petroleum oil over the operating temperature range of 60 to 140 F. For the emulsion, the kinetic boundary friction values were approximately 0.1. Static coef-

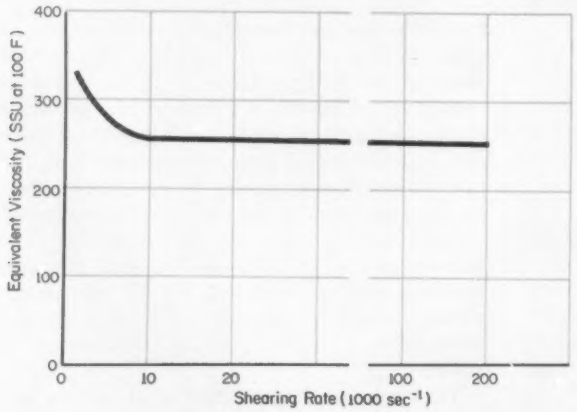


Fig. 2—Effect of shear rate on viscosity for a typical emulsion.

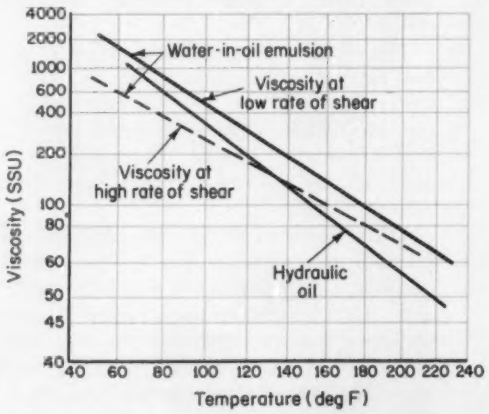


Fig. 3—Comparison of effect of temperature on viscosity for an emulsion and a petroleum hydraulic oil.

ficient of friction ranged from 0.1 for steel on bronze, to 0.2 for steel on steel and cast iron. The values were essentially the same for the oil.

Experience indicates that a stable emulsion can be used satisfactorily in most vane, gear, and piston pumps and motors operated within manufacturers' recommended limits of temperature and pressure.

Compressibility: An important factor in the design of precision hydraulic control systems is the compressibility of the hydraulic fluid. Table 2 shows this characteristic for a typical water-in-oil emulsion and a conventional hydraulic oil of high viscosity index. These data indicate that at lower pressures the emulsion is slightly more compressible than a comparable oil.

Corrosion and Rust Protection: Satisfactory corrosion protection can be obtained with these fluids. Sandblasted steel tags, suspended in operating systems, show only a slight stain after several hundred hours of exposure. Unprotected control tags show rust in a few hours of outdoor exposure.

Corrosion tests indicated no change in aluminum and only a slight discoloration of copper, zinc, brass, cadmium, and magnesium. There was no evidence of pitting or metal attack on the test panels. The use of a water-containing fluid in continuous contact with magnesium is generally not recommended. However, repeated tests with molten magnesium indicate that the oil-coated water particles normally do not come in contact with the metal.

Rusting has been experienced in the unprotected upper vapor space of some reservoirs in which the emulsions are used. These areas, which are usually several feet above the fluid level in the reservoir, are not reached by the normal splash and mist of oil. Small quantities of moisture evaporating from the fluid or entering the reservoir from the outside atmosphere condense on the cooler upper surfaces and promote rusting. Protective coatings or fluid periodically splashed against these surfaces provides adequate protection.

Seals and Packings: Since the continuous phase of the water-in-oil emulsion is normally a well refined, inhibited hydraulic oil, the emulsion is compatible with most conventional seal and packing materials. The exceptions are uncoated cork, leather, and other nonwaterproofed fibrous materials which will swell and disintegrate in the presence of water. Butyl rubber seals and hoses, normally used with synthetic fire-resistant fluids, will swell beyond acceptable limits in the water-in-oil emulsions, as well as in conventional oils.

Table 2—Viscosity of a Typical Emulsion*

Temp (F)	Viscosity (cs)	Viscosity (SSU)	Viscosity under Shear† (poise)	Viscosity under Shear† (SSU)
40	475	2200	....	...
70	171	788	....	...
100	78.4	362	0.502	235
140	36.0	168	0.254	135
180	19.9	97.8	....	...

*Viscosity Index—145
†Shear Rate—10,000 sec^{-1}

Table 3—Hydraulic-Fluid Compressibility

Pressure (psi)	Compressibility (%) Emulsion	Compressibility (%) Oil	Bulk Modulus (psi) Emulsion	Bulk Modulus (psi) Oil
2,000	1.2	0.8	167,000	250,000
4,000	1.9	1.5	211,000	267,000
6,000	2.5	2.1	240,000	286,000
8,000	3.0	2.8	267,000	286,000
10,000	3.5	3.4	286,000	294,000
20,000	5.7	5.8	352,000	345,000
30,000	7.6	7.7	394,000	389,000
40,000	9.3	9.4	430,000	426,000
50,000	10.8	10.8	463,000	463,000

Paints and Pipe Dopes: Emulsion-type fluids differ widely in their compatibilty with oil-resistant paints. Most of the compatibility problems are caused by poor paint bonding or insufficient drying time.

Pipe dopes and sealers are compatible with water-in-oil emulsions. However, some pipe dopes and sealers cause foaming with either oil or the emulsions if used in excess. Water-resistant type grease should be used as pipe-thread lubricants or in pump bearings if there is any possibility that grease may enter the fluid system through seal failures.

Compatibility with Other Fluids: The water-in-oil emulsions are compatible with neutral petroleum-hydraulic oils and can replace them directly in most clean systems. However, mixing with these oils should be kept to a minimum to maintain adequate fire resistance. For convenience and economy, many machine builders test new equipment, destined for use with emulsions, using normal test oil. This oil is drained before sealing the equipment for shipment. The emulsion can be added at the customer's plant after removing any debris picked up during shipment and installation.

Oxidized oils and sludges should be removed from older equipment being converted to these fluids. The emulsions are detergent, and provide excellent cleaning of such systems. The stability of the emulsion may be reduced while removing these acidic sludges. Therefore, the flushing charge should be replaced after several days of operation.

The emulsion-type fluids are not compatible with the water/glycol or phosphate-ester types of fire-resistant fluids. Water-in-oil emulsions available from different manufacturers are not necessarily compatible.

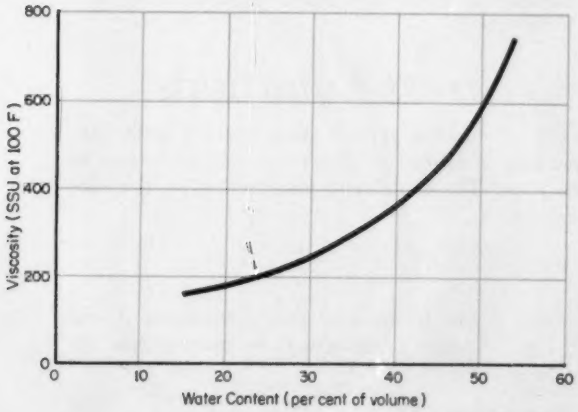
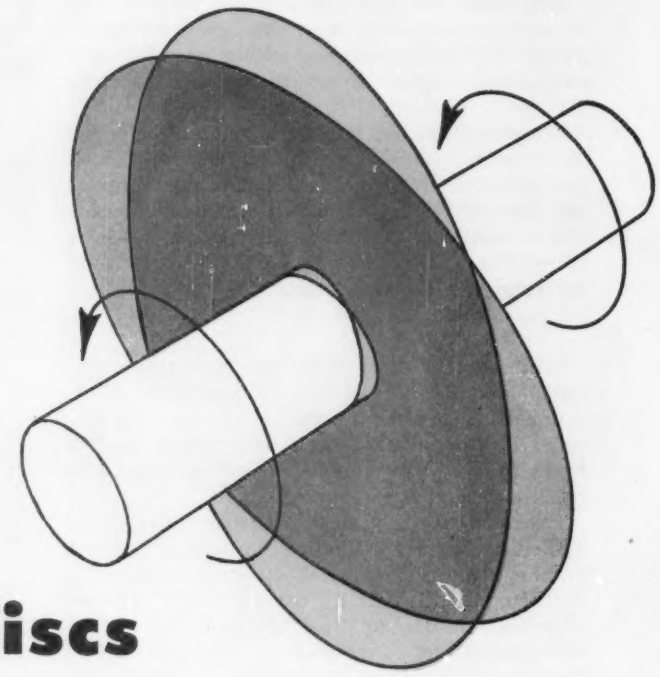


Fig. 4—Effect of water content on viscosity for a typical emulsion.

Determining Stresses in **Tilted Rotating Discs**



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Conventional methods for analyzing stresses in a rotating disc are usually based on the assumption that the plane of the disc is perpendicular to the axis of rotation.

In practice, however, this assumption is not always fulfilled and the disc may be tilted at an angle to the perpendicular. The tilt angle may be fairly large and intentional, as in the wobble or swash plate of a piston pump, or it may be small and unintentional, as in a compressor or turbine rotor which is not perfectly aligned on the shaft in assembly. Total stresses in a circular disc rotating at constant speed about an axis which is tilted slightly from the disc axis can be estimated with the aid of the charts and equations presented in this article.

THIS analysis is based on the theory of small lateral deflections of thin elastic plates. This theory assumes that the plate is relatively thin; is made of a homogeneous, isotropic, elastic material; and undergoes relatively small deflections. Additional assumptions for this analysis are, Fig. 1:

1. Plate is of uniform thickness.
2. Midplane of the plate is in the form of a circular annulus.
3. Plate is rigidly clamped along its inside radius.
4. Angle of tilt is small enough that its cosine may be considered to be equal to unity.
5. Effects of lateral loading and in-plane loading do not interact.

Stress Equations

Fig. 1 shows a typical small element with surface area A located at distance r from the center of the plate. The centrifugal force acting on this element is:

$$F = \frac{\gamma \omega^2 h A r \cos \alpha}{g} \qquad (1)$$

Force F can be resolved into components P and Q, Fig. 1. Angle α will always be smaller than tilt angle α_0 because

$$\sin \alpha = \sin \alpha_0 \cos \theta \qquad (2)$$

Since α_0 has been assumed to be small, α will always

*The author's initial work on this topic was performed at Battelle Memorial Institute, Columbus, Ohio.

Nomenclature

A = Elemental area
a, b = Outside and inside radii of disc, in.
C = Stress factor (Equation 8), psi
D = Flexural rigidity of disc
E = Young's modulus of disc material, psi
F = Elemental resultant centrifugal force
g = Gravitational acceleration, 386 in. per sec per sec
h = Disc thickness, in.
P, Q = In-plane and normal components of centrifugal force
p = Shrink-fit pressure, psi
q = Normal pressure due to centrifugal action on tilted disc
r = Radius measured in plane of disc
S_e = Maximum effective stress, psi
S_r, S_t = Radial and tangential centrifugal-bending stresses
S_{rb}, S_{tb} = Radial and tangential centrifugal-bending stresses at bore, psi
S_{rb}', S_{tb}' = Radial and tangential centrifugal-stretching stresses at bore, psi
S_{rb}'', S_{tb}'' = Radial and tangential shrink-fit stresses at bore, psi
S_{rn}, S_{tn} = Radial and tangential net stresses at bore, psi
w = Lateral deflection
α = Angle between any radial line on disc and plane normal to rotational axis
α_0 = Tilt angle, deg
β = Inside-to-outside radius ratio $= b/a$
γ = Specific weight of disc material, lb per cu in.
δ = Radial shrink-fit interference, in.
ν = Poisson's ratio of disc material
ω = Rotational velocity, radians per sec
ρ = Elemental radius ratio $= r/a$
θ = Angular position on disc, measured from a radial line on the disc at 90 deg to the tilt axis

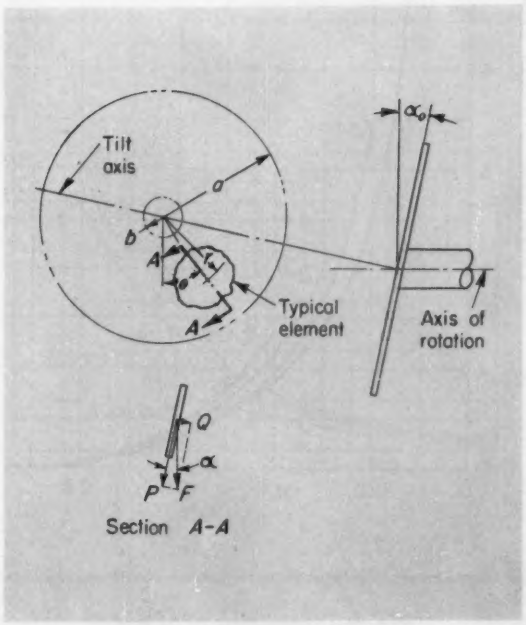


Fig. 1—Disc geometry and force analysis of a typical element.

be small. Thus, component P, which acts in the plane of the disc, is practically as large as force F. Therefore, the stresses resulting from stretching in the plane of the disc must be nearly as large as the centrifugal stresses in an untilted disc.

Component Q, which acts normal to the plane of the disc, equals $F \sin \alpha$. Then, normal pressure q, which is the normal force per unit area (Q/A), is:

$$q = \frac{\gamma \omega^2 h r \sin \alpha \cos \alpha}{g} \qquad (3)$$

Assume angle α is small enough that $\cos \alpha$ can be approximated by unity. Then Equation 2 can be substituted into Equation 3 and the result simplified to

$$q = \frac{K r \cos \theta}{a} \qquad (4)$$

where $K = (\gamma \omega^2 h\, a \sin \alpha_0)/g$.

Fig. 2 shows the normal-pressure distribution, which varies linearly with radius r, on a cross section of the disc perpendicular to the tilt axis.

The in-plane stretching loading and the normal-pressure loading occur simultaneously. Deflections produced by one kind of loading affect the deflections due to the other. Thus, an exact solution must

involve an interaction of the two loadings, analogous to the effect of axial loading and lateral loading in a beam column. However, it is assumed here that the two loadings are superposable. For small deflections, the error due to this assumption is small.

The general solution for the lateral deflection, at any radius ratio ρ, of a uniform-thickness circular plate subject to the normal-pressure distribution given by Equation 4 is:[1]

$$w = \frac{K b^4}{192\,D} \times \left(\rho^5 + C_1\rho + C_2\rho^3 + \frac{C_3}{\rho} + C_4\rho \ln \rho \right) \cos\theta \qquad (5)$$

[1]References are tabulated at end of article.

The four constants of integration C_1, C_2, C_3, and C_4, can be evaluated by considering the four boundary conditions. Deflection and slope are zero at the bore. Shear force and radial bending moment are zero at the outer periphery, which is a free edge.

Substituting appropriate values for the constants, rearranging, and simplifying gives the radial and tangential bending stresses due to the tilt of the disc axis at any radius ratio ρ and angular position θ,

$$S_r = -4 \left[4(5+\nu)\rho^3 + 2(3+\nu)C_2\rho + \frac{2(1-\nu)C_3}{\rho^3} + \frac{12(1+\nu)}{\rho} \right] C \cos\theta \qquad (6)$$

Table 1—Stress Summary

Stress Type	Radial Stress (psi)	Tangential Stress (psi)
Bending due to tilt	109,000	32,500
Stretching	.....	54,000
Shrink Fit	—10,700	11,200
Total	98,300	97,700

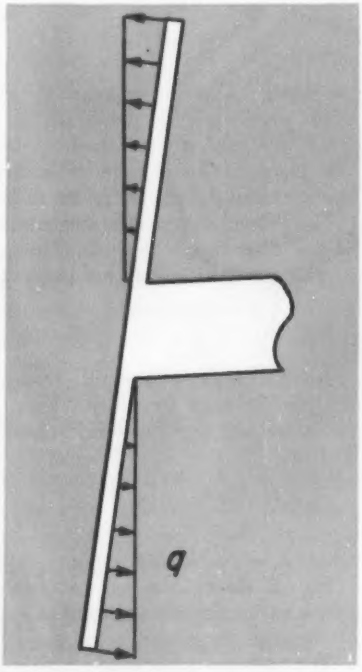


Fig. 2—Distribution of normal pressure due to centrifugal action.

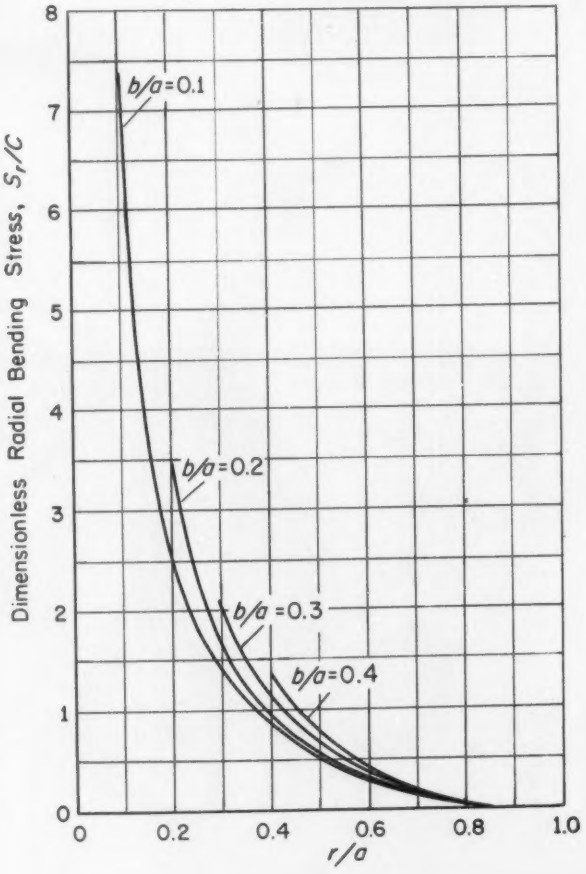


Fig. 3—Dimensionless radial bending stress distribution.

and

$$S_t = -4\left[4(1+5\nu)\rho^3 + 2(1+3\nu)C_2\rho - \frac{2(1-\nu)C_3}{\rho^3} + \frac{12(1+\nu)}{\rho}\right] C\cos\theta \qquad (7)$$

where

$$C = \frac{\gamma\omega^2 a^3 \sin\alpha_0}{gh} \qquad (8)$$

Design Curves

Fig. 3 and 4 show the distribution of the radial and tangential bending stresses as calculated from Equations 6 and 7. The stresses are shown along a radial line at $\theta = 180$ deg (Fig. 1) which gives the maximum values. The values are shown for discs having various ratios of inside radius to outside radius and a Poisson's ratio of 0.30. (Changing the value of Poisson's ratio over the range of values usually encountered, 0.25 to 0.35, has a negligible effect on the stress distribution.) Since the stresses are given in dimensionless form, the data are applicable to discs of any dimensions.

Note that the tangential stresses reach maximum values at definite distances from the clamped inside edge, while the radial stresses are always maximum at the clamped edge.

Qualitatively, the stress distribution is quite similar to that encountered in gyroscopic loading.[2] However, the centrifugal-bending stresses are steady rather than time-varying as they are in gyroscopic loading. The tilt axis rotates with the impeller. Thus, any point on the disc always has the same offset, and is subject to the same centrifugal bending moment.

The maximum bending stress, which is in the radial direction, and the maximum centrifugal-stretching stress, which is tangential, are both maximum at the inside radius. Therefore, the combined stress here is always the largest, and thus governs the design. Fig. 5 shows the radial and tangential

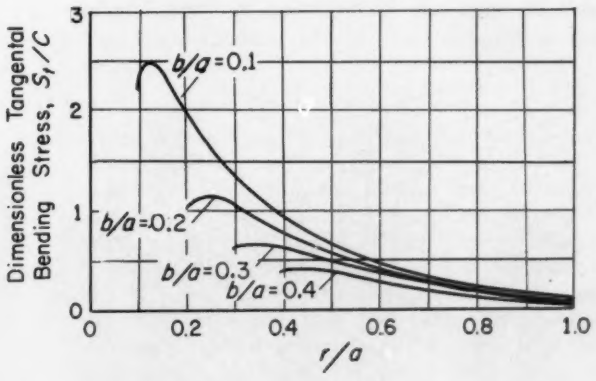


Fig. 4 — Dimensionless tangential bending stress distributions.

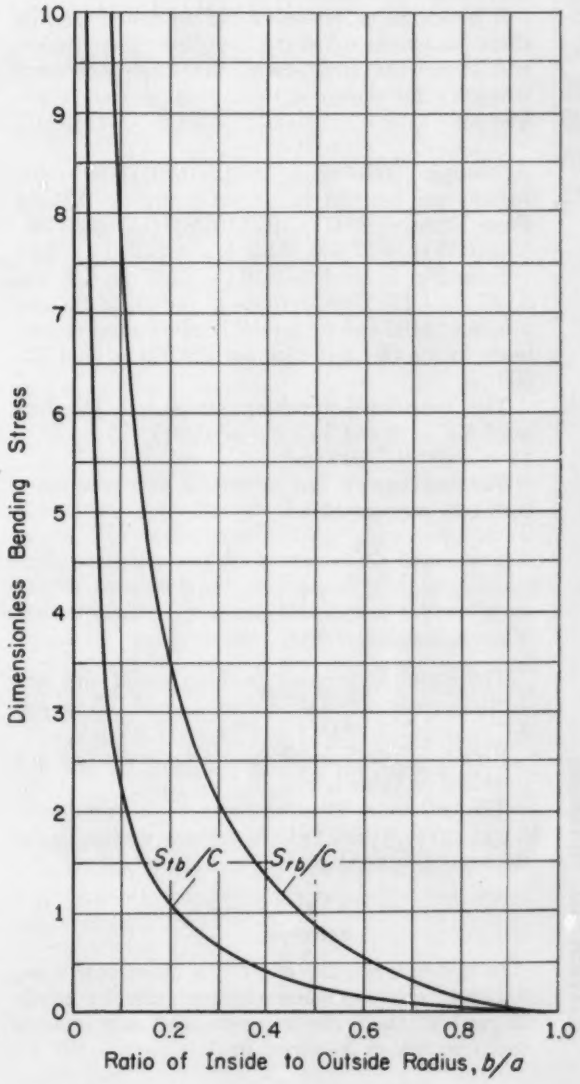


Fig. 5—Effect of inside-to-outside radius ratio on the dimensionless radial and tangential bending stresses at the inside edge of disc.

bending stresses at the inside edge as a function of the inside-to-outside radius ratio.

Practical Example

A circular steel disc, rotating at 6000 rpm, has the following characteristics: Outside radius $a = 15$ in., thickness $h = 0.75$ in., inside radius $b = 2.25$ in., tilt angle $\alpha_0 = 1$ deg, specific weight $\gamma = 0.283$ lb per cu in., Poisson's ratio $\nu = 0.30$, and Young's modulus $E = 29.5 \times 10^6$ psi.

The disc has been shrunk on the shaft to provide a diametral interference of 0.0022 in. at operating temperature and stationary conditions.

It is desired to determine the maximum effective stress (sometimes called the von Mises yield criterion, and, somewhat erroneously, the distortion-energy strength) for design against yielding and fatigue fracture.

Solution: Velocity $\omega = [2\pi(6000)]/60 = 628$ radians per sec; sin α_0 = sin 1 deg = 0.01745. From Equation 8, $C = 0.283(628)^2(15)^3(0.01745/[386(0.75)] = 22{,}800$. Also, $b/a = 2.25/15 = 0.15$.

From Fig. 5, for $b/a = 0.15$, $S_{rb}/C = 4.80$ and $S_{tb}/C = 1.43$. Thus, because of the tilt of the disc axis, the radial and tangential bending-stress components at the clamped edge are 109,000 psi and 32,500 psi.

The centrifugal-stretching stresses at the bore are:[3] $S_{rb}' = 0$ and $S_{tb}' = (\gamma\omega^2 a^2/4g)\,[(3 + \nu) + (1 - \nu)\beta^2] = 54{,}000$ psi.

The interference ($2\delta = 0.0022$ in.) produces a shrink-fit pressure of:[3]

$$p = \frac{E\,\delta}{b\left(\dfrac{1+\beta^2}{1-\beta^2} + \nu\right)}$$

$$= 10{,}700 \text{ psi}$$

The shrink fit pressure produces radial and tangential stresses of:[3] $S_{rb}'' = -p = -10{,}700$ psi and $S_{tb}'' = p\,[(1 + \beta^2)/(1 - \beta^2)] = 11{,}200$ psi.

Results of these calculations are summarized and combined in Table 1.

The maximum effective stress for a two-dimensional stress system (which neglects stresses in the thickness direction) is:

$$S_e = \sqrt{S_{rn}^2 - S_{rn}\,S_{tn} + S_{tn}^2}$$

$$= 98{,}000 \text{ psi}$$

In this instance, the effect of a tilt of only 1 deg increased the maximum effective stress by nearly 38 per cent above the stress produced as a result of stretching and of the shrink fit.

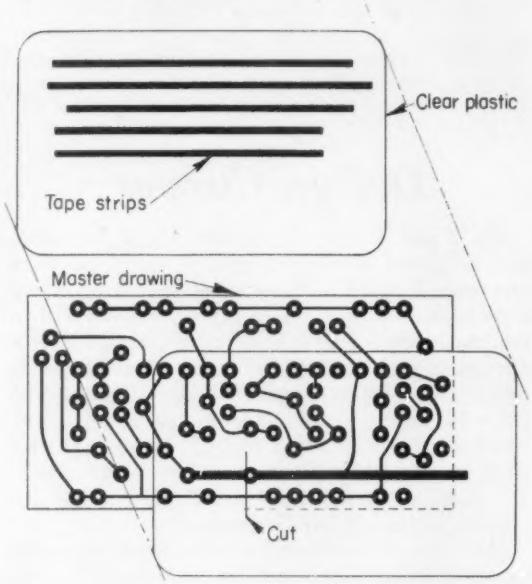
REFERENCES

1. S. P. Timoshenko and S. Woinowsky-Krieger—*Theory of Plates and Shells*, second edition, McGraw-Hill Book Co., New York, 1959, p. 286.
2. M. H. Hirschberg and A. Mendelson—"Analysis of Stresses and Deflections in a Disc Subjected to Gyroscopic Forces," *NACA* 4218, Mar. 1958.
3. R. J. Roark—*Formulas for Stress and Strain*, third edition, McGraw-Hill Book Co., New York, 1954.

Tips and Techniques

Printed Circuit Masters

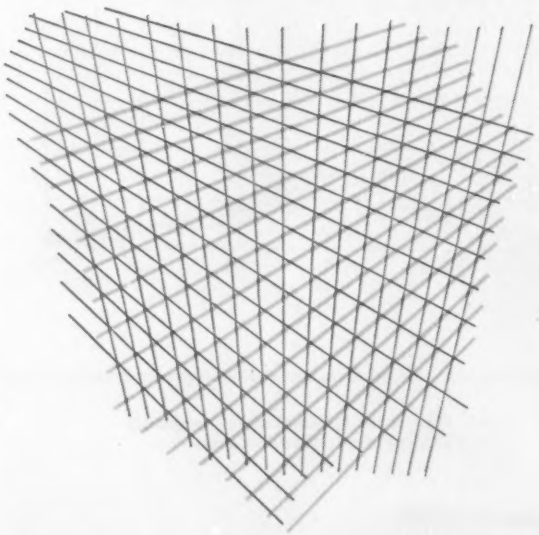
Attaching strips of tape to a transparent plastic sheet speeds layout of printed circuit masters. The tape is superimposed directly over the pads to be



joined on the master, and cut to exact size. It is then removed from the sheet and placed in position. —ROBERT A. DOVE, *West Palm Beach, Fla.*

Improved Trace Charts

Trace charts for isometric or perspective drawings can be modified easily to a form that simplifies their use and eliminates the confusion of intersecting lines. The modification consists of tracing the chart on vellum using a different colored ink for each direction.—W. H. SHEPPARD, *Montreal, Quebec*



Moment of Inertia Charts

Grid layout and construction details of charts for finding moment of area and moment of inertia of irregular shapes.

ROBERT A. JOHNS
Director of Product Development
Belle City Malleable Iron Co.
Racine, Wis.

A SIMPLE method for determining the approximate area of an irregular shape is to count the squares enclosed by the shape on an overlay grid. That same technique is used in this article for determining moment of area and moment of inertia. When this method is used with reasonable care, inaccuracy should not exceed 3 to 5 per cent.

Moment of Area: Grid layout and construction details for a moment of area chart are given in Fig. 1. Construction of this chart is based on the relationship,

$$\Sigma Ay = A_1y_1 + A_2y_2 + A_3y_3 \ldots$$

where A is area and y is the distance from the centroid of the area to a base line.

In Fig. 1, the grid divides the chart area into small rectangular sections. In the region of the chart from the base line to a height of 1 in., each rectangle 1 in. long has a moment of area of 0.1 in.^{3} about the base line. In the region between 1 and 5 in. above the base line, each 1 in. long rectangle has a value of 0.5 in.^{3}, and in the region above the 5 in. height, the value for each 1 in. rectangle is 1.0 in.^{3}

To simplify use of the chart, the 1 in. rectangles in these two upper regions are further subdivided into sections having moment values of 0.1 in.^{3} Also, minimum heights of horizontal bands in each region are kept to 0.10 in. for ease in counting.

To determine the moment of area of a part with this chart, a tracing of the part shape is placed on the chart with the selected principal axis parallel to the base line and the bottom of the figure tangent to the base line. All of the rectangular sections (corresponding to moment values of 0.1 in.^{3}) enclosed by the figure are then counted. Rectangles not completely enclosed are estimated. The total number of rectangles, divided by ten, is the moment of area of the shape.

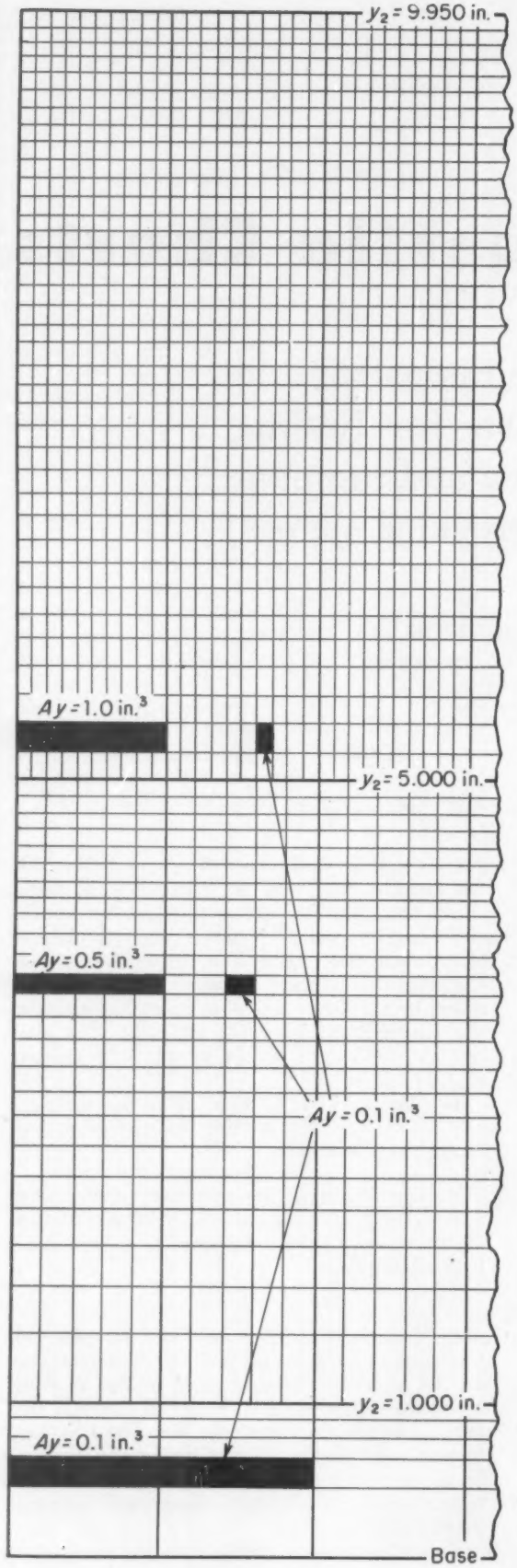
The distance from the base line to the centroidal axis can be found by dividing the moment of area by the area of the shape.

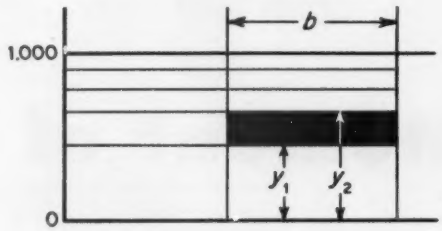
Moment of Inertia: The same general method of construction is used for the moment of inertia chart, Fig. 2, as was used for the moment of area chart. Basic relationship is

$$\Sigma I = I_1 + I_2 + I_3 \ldots$$

where I is the moment of inertia of an area with respect to a base line or axis. Co-ordinates (y_2) for the horizontal lines are listed in Fig. 2. Here, again, each rectangle 1 in. long has a certain moment of inertia about the base line. The 1 in. long rectangles are divided so that the smallest sections in the bottom three regions equal 0.1 in.^{4} In all regions above the bottom three, each rectangle equals 1.0 in.^{4}

This chart is used similarly to the moment of



Basic Relationships

$$Ay = b(y_2 - y_1)\frac{y_2 + y_1}{2} = \frac{b}{2}(y_2^2 - y_1^2)$$

For this chart, $b = 1$ in., and y_1 is y_2 of next lower band. Also, for region between 0 and 1.000 in. above base, $Ay = 0.1$ in.^{3} Then,

$$\frac{y_2^2 - y_1^2}{2} = 0.1 \text{ in.}^3$$

and

$$y_2 = \sqrt{0.2 + y_1^2}$$

For region between 1.000 and 5.000 in. above base, $Ay = 0.5$ in.^{3}, and

$$y_2 = \sqrt{1 + y_1^2}$$

For region between 5.000 and 9.950 in. above base, $Ay = 1.0$ in.^{3} and

$$y_2 = \sqrt{2 + y_1^2}$$

Grid Layout

y_1	y_2^2	$y_2 - y_1$	y_1	y_2^2	$y_2 - y_1$
	$Ay = 0.1$ in.^{3} per in., $y_2^2 = 0.2 + y_1^2$				
0	0.2	0.447	0.775	0.8	0.119
0.447	0.4	0.185	0.894	1.0	0.106
0.632	0.6	0.143			
	$Ay = 0.5$ in.^{3} per in., $y_2^2 = 1.0 + y_1^2$				
1.000	2.0	0.414	3.606	14.0	0.136
1.414	3.0	0.318	3.742	15.0	0.131
1.732	4.0	0.268	3.873	16.0	0.127
2.000	5.0	0.236	4.000	17.0	0.123
2.236	6.0	0.213	4.123	18.0	0.120
2.449	7.0	0.197	4.243	19.0	0.116
2.646	8.0	0.182	4.359	20.0	0.113
2.828	9.0	0.172	4.472	21.0	0.111
3.000	10.0	0.162	4.583	22.0	0.107
3.162	11.0	0.155	4.690	23.0	0.106
3.317	12.0	0.147	4.796	24.0	0.103
3.464	13.0	0.142	4.899	25.0	0.101
	$Ay = 1.0$ in.^{3} per in., $y_2^2 = 2.0 + y_1^2$				
5.000	27.0	0.196	7.937	65.0	0.125
5.196	29.0	0.189	8.062	67.0	0.123
5.385	31.0	0.183	8.185	69.0	0.122
5.568	33.0	0.177	8.307	71.0	0.119
5.745	35.0	0.171	8.426	73.0	0.118
5.916	37.0	0.167	8.544	75.0	0.116
6 083	39.0	0.162	8.660	77.0	0.115
6.245	41.0	0.158	8.775	79.0	0.113
6.403	43.0	0.154	8.888	81.0	0.112
6 557	45.0	0.151	9.000	83.0	0.110
6.708	47.0	0.148	9.110	85.0	0.110
6.856	49.0	0.144	9.220	87.0	0.107
7.000	51.0	0.141	9.327	89.0	0.107
7.141	53.0	0.139	9.434	91.0	0.105
7.280	55.0	0.136	9.539	93.0	0.105
7.416	57.0	0.134	9.644	93.0	0.103
7.550	59.0	0.131	9.747	97.0	0.102
7.681	61.0	0.129	9.849	99.0	0.101

Fig. 1—Grid layout and basic relationships for moment of area chart.

Basic Relationships

$$I = \frac{b}{3}(y_2^3 - y_1^3)$$

For this chart, $b = 1$ in., and y_1 is y_2 of next lower band. Also, for region between 0 and 1.063 in. above base, $I = 0.1$ in.^{4} Then,

$$\frac{y_2^3 - y_1^3}{3} = 0.1 \text{ in.}^4$$

and

$$y_2 = \sqrt[3]{0.3 + y_1^3}$$

For region between 1.063 and 1.442 in. above base, $I = 0.2$ in.^{4}, and

$$y_2 = \sqrt[3]{0.6 + y_1^3}$$

For region between 1.442 and 3.208 in. above base, $I = 1.0$, and

$$y_2 = \sqrt[3]{3.0 + y_1^3}$$

Similar relationships can be found for $I = 2, 3, 4, 5, 6, 8$ and 10 in.^{4}

Grid Layout

y_1	y_2^3	$y_2 - y_1$	y_1	y_2^3	$y_2 - y_1$
	$I = 0.1$ in.^{4} per in., $y_2^3 = 0.3 + y_1^3$				
0	0.3	0.669	0.843	0.9	0.123
0.669	0.6	0.174	0.966	1.2	0.097
	$I = 0.2$ in.^{4} per in., $y_2^3 = 0.6 + y_1^3$				
1.063	1.8	0.153	1.339	3.0	0.103
1.216	2.4	0.123			
	$I = 1.0$ in.^{4} per in., $y_2^3 = 3.0 + y_1^3$				
1.442	6	0.375	2.621	21	0.138
1.817	9	0.263	2.759	24	0.125
2.080	12	0.209	2.884	27	0.116
2.289	15	0.177	3.000	30	0.107
2.466	18	0.155	3.107	33	0.101
	$I = 2.0$ in.^{4} per in., $y_2^3 = 6.0 + y_1^3$				
3.208	39	0.183	3.979	69	0.123
3.391	45	0.166	4.102	75	0.115
3.557	51	0.151	4.217	81	0.110
3.708	57	0.141	4.327	87	0.104
3.849	63	0.130	4.431	93	0.100
	$I = 3.0$ in.^{4} per in., $y_2^3 = 9.0 + y_1^3$				
4.531	102	0.141	5.168	147	0.110
4.806	120	0.126	5.278	156	0.105
4.932	129	0.121	5.383	165	0.102
5.053	138	0.115			
	$I = 4.0$ in.^{4} per in., $y_2^3 = 12.0 + y_1^3$				
5.485	177	0.130	5.972	225	0.110
5.615	189	0.124	6.082	237	0.106
5.739	201	0.119	6.188	249	0.103
5.858	213	0.114	6.291	261	0.100
	$I = 5.0$ in.^{4} per in., $y_2^3 = 15.0 + y_1^3$				
6.391	276	0.120	6.739	321	0.108
6.511	291	0.116	6.847	336	0.105
6.627	306	0.112	6.952	351	0.102
	$I = 6.0$ in.^{4} per in., $y_2^3 = 18.0 + y_1^3$				
7.054	369	0.119	7.399	423	0.108
7.173	387	0.114	7.507	441	0.105
7.287	405	0.112	7.612	459	0.102
	$I = 8.0$ in.^{4} per in., $y_2^3 = 24 + y_1^3$				
7.714	483	0.132	8.335	603	0.113
7.846	507	0.128	8.448	627	0.111
7.974	531	0.124	8.559	651	0.108
8.098	555	0.120	8.667	675	0.105
8.218	579	0.117	8.772	699	0.103
	$I = 10.0$ in.^{4} per in., $y_2^3 = 30.0 + y_1^3$				
8.875	729	0.125	9.469	879	0.110
9.000	759	0.122	9.579	909	0.108
9.122	789	0.118	9.687	939	0.105
9.240	819	0.116	9.792	969	0.104
9.356	849	0.113	9.896	999	0.101

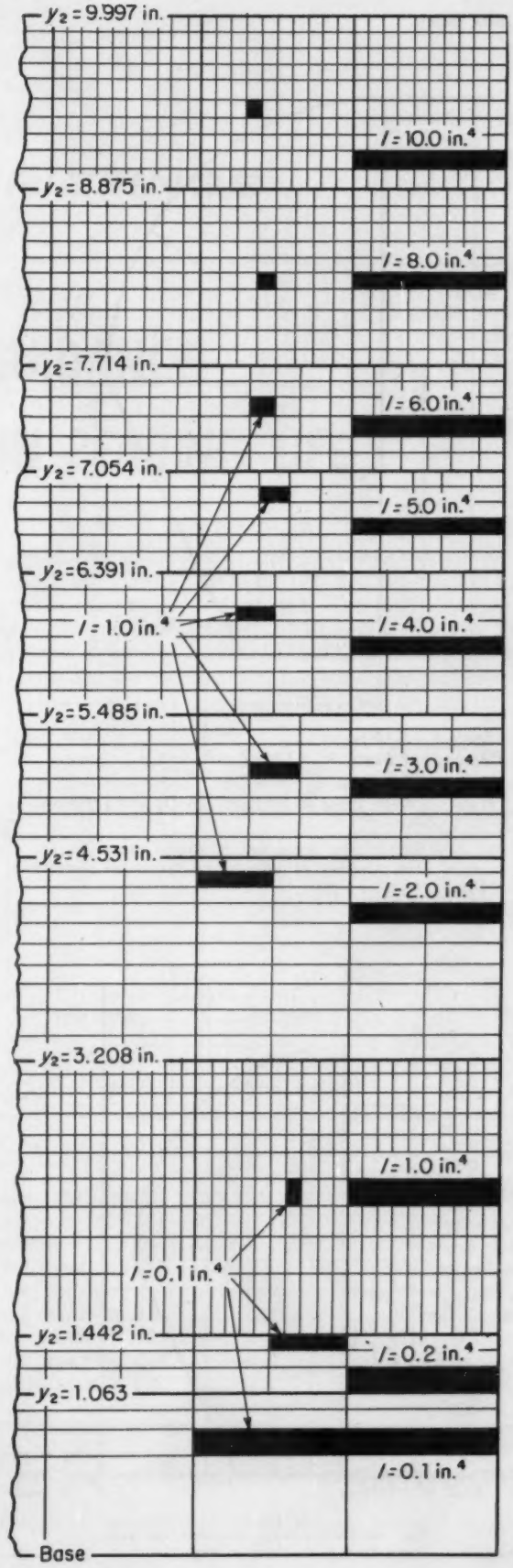
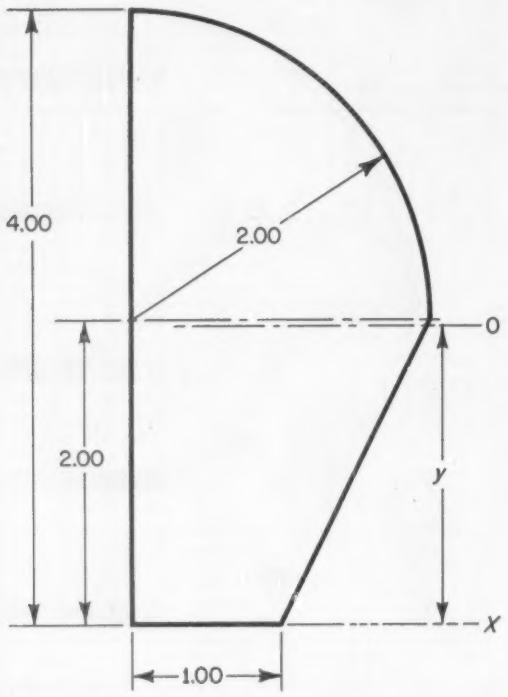


Fig. 2—Grid layout and basic relationships for moment of inertia chart.



Area, A = 6.14 sq in.
Moment of Area, M_X = 12.27 in.^{3}
Moment of Inertia, I_0 = 6.47 in.^{4}
Distance from Base X to Centroid 0, y = 1.998 in.

Fig. 3—Example part shape and calculated values for moment of area, moment of inertia, and centroidal distance.

area chart, but there are two points of caution. First, remember that the values of the smallest rectangles change between the 1 in.^{4}-per-in. and the 2 in.^{4}-per-in. regions. Second, for moments of inertia about the centroid, greater accuracy will result if the centroidal axis is placed on the base line of the chart. The use of the transfer formula, $I_0 = I_x - Ay^2$, can result in large errors in the value of moment of inertia if there is a small error in y. The moment of inertia should be determined by the method shown in the examples unless the shape is symmetrical. In that case, the value determined for one half the shape can be doubled.

Chart Examples: Fig. 3 shows a simple part shape along with the values of moment of area and moment of inertia as calculated directly. Graphical methods of calculating these values with the charts, Fig. 1 and 2, are demonstrated in Fig. 4 and 5.

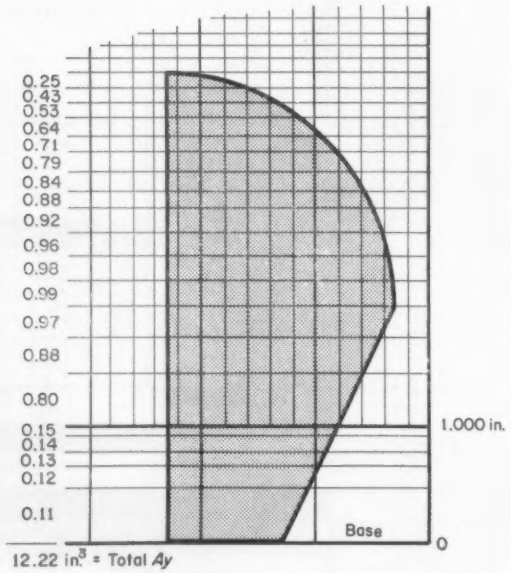


Fig. 4—Determining moment of area about base with chart in Fig. 1.

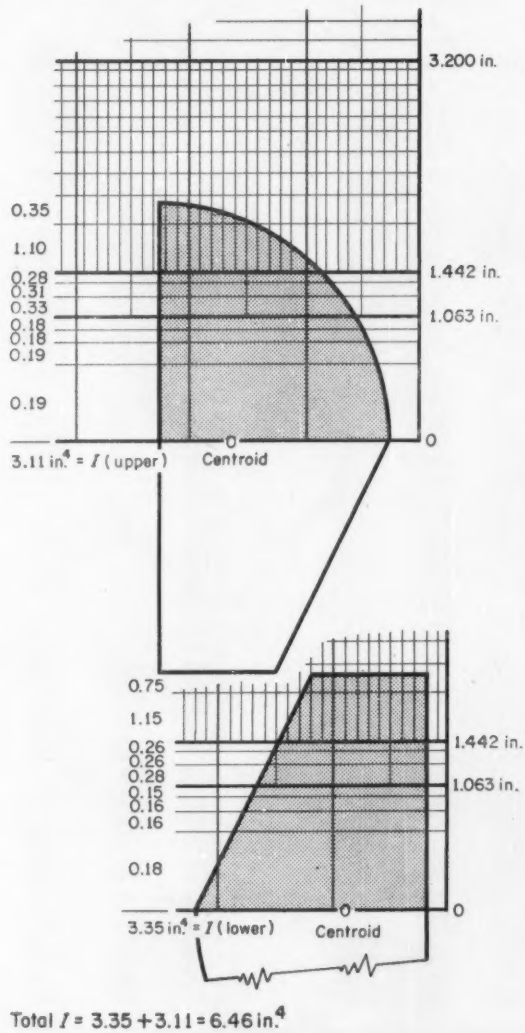


Fig. 5—Determining moment of inertia about the centroid with chart in Fig. 2.

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

One in a series of technical reports by Bower

BEARING BRIEFINGS

ROLLER GUIDANCE— VITAL FACTOR IN BEARING LIFE

Roller guidance has been established by the Anti-Friction Bearing Manufacturers Association as a major rating factor for roller bearings. There is a direct relationship between this factor and the life and capacity of a cylindrical roller bearing under load.

Figure 1 illustrates the results of a loose fit between a roller and the guiding ribs of the raceway. Because of lack of guidance by the ribs, the roller is free to skew and skid under load. Such a condition invariably leads to early bearing failure.

To achieve close roller fit and proper roller guidance, Bower precision grinds each bearing race on specially designed centerless grinders. In this operation, Bower positions the integral raceway ribs *from the theoretical centerline of the bearing*. This method produces bearings with high dimensional accuracy and perfect symmetry.

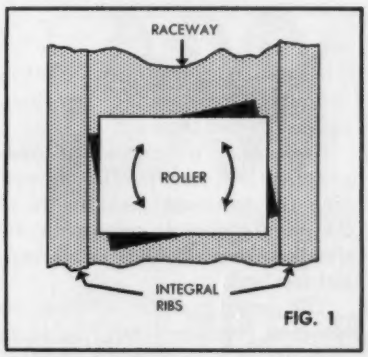
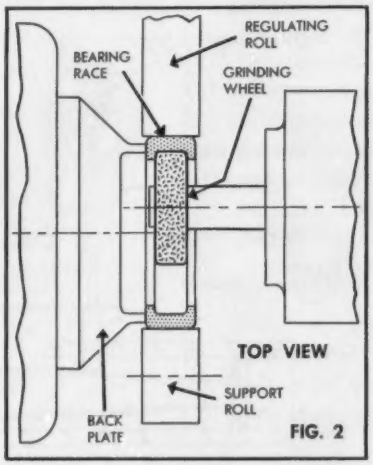
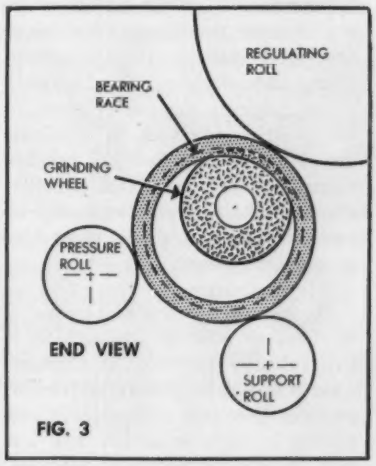


Fig. 1. Loose fit in raceway means poor roller guidance. Roller can skew and skid under load.

In addition, the close tolerances held in grinding the roller track and integral guiding ribs give Bower cylindrical roller bearings the ability to *take thrust in any direction*. A Bower cylindrical roller bearing has thrust capacity of from 10-15% of its rated radial capacity!



Figures 2 and 3 diagram the centerless grinding method used to finish Bower raceways. Use of this technique assures not only optimum roller guidance and maximum bearing life, but also virtually eliminates bearing runout. BEARING SYMMETRY WHICH RESULTS FROM THIS TECHNIQUE PERMITS ACCURATE SHAFT LOCATION REGARDLESS OF HOW THE OUTER RACE AND ROLLER ASSEMBLY ARE INSTALLED. IT COMPLETELY ELIMINATES THE POSSIBILITY OF IMPROPER INSTALLATION.



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New application techniques for

Electrohydraulic Servomechanisms

KENNETH D. GARNJOST
Corporate Technical Consultant

HARVARD B. KOLM
Manager, Industrial Div.

MOOG Servocontrols, Inc.
East Aurora, N. Y.

AIRCRAFT-TYPE electrohydraulic servo components and techniques have been extensively adapted, in recent years, for nonairborne use where high dynamic response and high accuracy are of prime importance. This article describes two of these techniques which were developed originally to improve simplicity and reliability. The first technique concerns the use of mechanical position feedback to eliminate the necessity for electrical position transducers and associated circuitry. The second technique uses load pressure feedback within a servovalve to augment system stability.

Mechanical Feedback: The use of mechanical position feedback in a hydraulically powered servomechanism is not an innovation in itself. It provides directness and simplicity, resulting in high reliability and low cost. The introduction of electrical control increases flexibility of performance. Recently, however, in missiles and aircraft, the directness and simplicity of mechanical feedback has been "rediscovered" with the aim of achieving higher reliability. Resulting devices have some significant differences from earlier industrial usage of this technique.

Good performance of such devices requires good linearity of input and feedback elements, low mechanical hysteresis (primarily friction) and, in the electrical case, low magnetic hysteresis in the motor. However, to provide reasonable operating forces, conventional motors of the "loudspeaker" type become fairly large and the moving parts relatively massive.

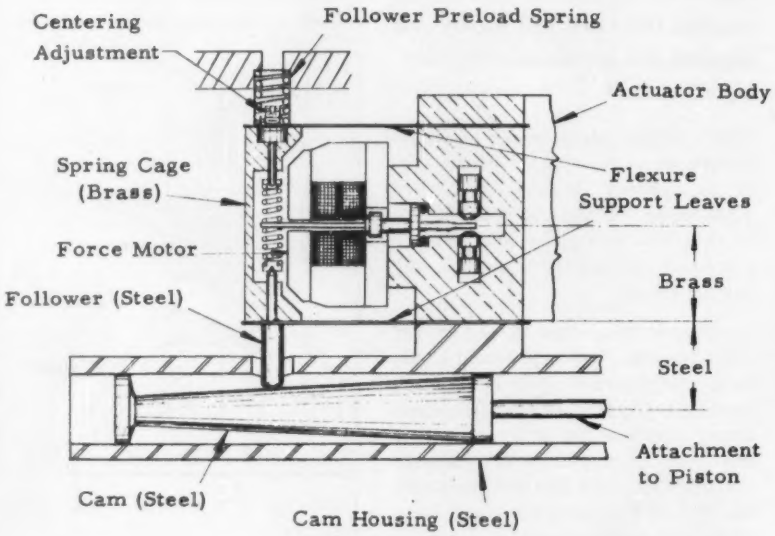

Fig. 1—Electrohydraulic servovalve having mechanical position feedback.

As a result of such inherent physical characteristics, servos employing these elements are necessarily limited. However, where relatively slow dynamic response and only fair resolution are required, these limitations are not felt. The electrohydraulic servo comes into use where these limitations are restrictive. The servo offers markedly higher servo loop gain to provide extremely fine resolution. Electrohydraulic servos permit these limitations to be overcome.

By making certain design compromises, it is now possible to combine the increased performance of the electrohydraulic servo with the simplicity and reliability of mechanical feedback.

The design problem is to use the low-mass, high-response, high-gain elements of aircraft-type electrohydraulic servovalves and to introduce

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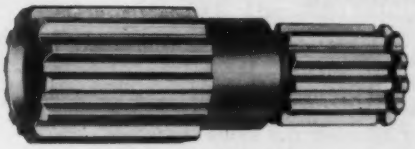

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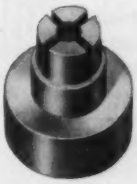

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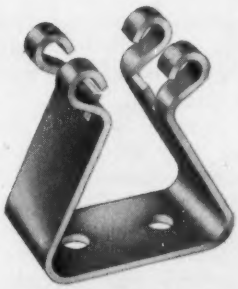

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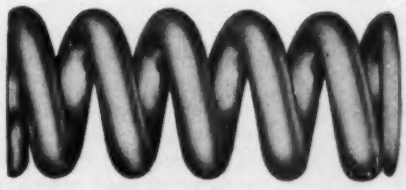

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mechanical feedback of the controlled element position. The obvious procedure is to connect a spring between the motor armature and the servo output motion. However, in such a high-performance device, previously negligible secondary factors become significant. A high-level vibration environment in many applications means that the feedback spring must be designed so that its natural frequencies are well above the frequency band of interest. At low-force levels, a small high-rate spring is required.

Unfortunately, a stiff feedback spring makes the mechanism very sensitive to small relative mechanical displacements such as produced by thermal expansion or slop in connections. An arrangement which overcomes these difficulties is shown in Fig. 1. Thermal drift is essentially eliminated by carefully matched thermal expansion paths. A conical cam is used because it lends itself readily to meeting the desired close dimensional and geometry tolerances.

Applications in which the advantages of an electrohydraulic servoactuator with integral mechanical feedback may be utilized are numerous. In large, low-pressure hydraulic systems, it is often necessary to use an electrohydraulic servovalve much larger than any presently available. An extremely high flow servovalve for limited applications is prohibitively expensive. However, such a valve may be effectively created by using a standardized mechanical feedback actuator to stroke the spool of a suitably large, four-way valve. Perhaps the most frequent applications requiring high response combined with high reliability are found in the throttle and bypass controls of steam and gas turbines.

Pressure Feedback: Electrohydraulic servos have been used in a number of applications in recent years in which a highly resonant, high-inertia load presented serious limitations on desired system stability and performance. Most of these applications are at relatively high output power levels and, therefore, the addition of direct, brute-force physical damping at the load is not only bulky but has to dissipate such large amounts of energy as to be totally impractical.

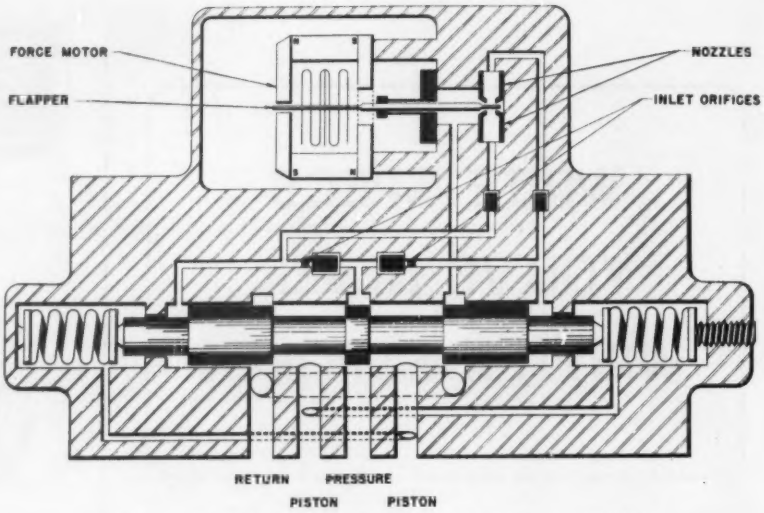

Fig. 2—Electrohydraulic servovalve with pressure feedback.

Under these conditions, it is desirable to introduce an incremental force on the load which is proportional to the velocity of the load, and, hence, appears as damping. By appropriate selection of values of various parameters, such as piston area, valve displacement per unit pressure, and valve flow gain, the damping can be made to have any desired value.

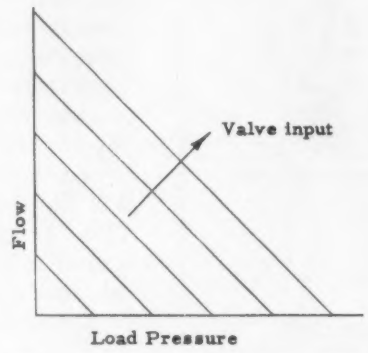

Fig. 3—Characteristics of a pressure feedback servovalve.

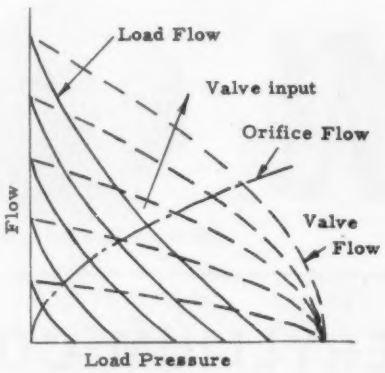

Fig. 4—Characteristics of an orifice bypass servovalve.

Incorporation of this pressure feedback into an electrohydraulic servovalve is shown in Fig. 2. By providing stub shafts on the ends of the valve spool, two areas are created. One may be used for pressure feedback and the other for the conventional driving pressure proportional to an electrical signal. Static flow-pressure characteristics of this valve are shown in Fig. 3. For comparison, Fig. 4 shows characteristics created by connecting a fixed orifice across the output of a conventional closed center servovalve. This bypass orifice technique has been frequently used to provide resonant damping, but it is wasteful of hydraulic power. Both techniques produce effective load damping but suffer the disadvantage of greatly reduced static stiffness to hydraulic loads as compared to closed-center valves. The ability to overcome this deficiency by means of a relatively simple addition is a major advantage of pressure feedback.

A significant factor to be considered is that damping of the load is only required at frequencies in the vicinity of load resonance. Therefore, if the pressure feedback, which produces the required damping, is made frequency-selective, it is possible to obtain damping at the load resonant frequency without suffering loss in system stiffness at low frequencies. This frequency selectivity can be accomplished by means

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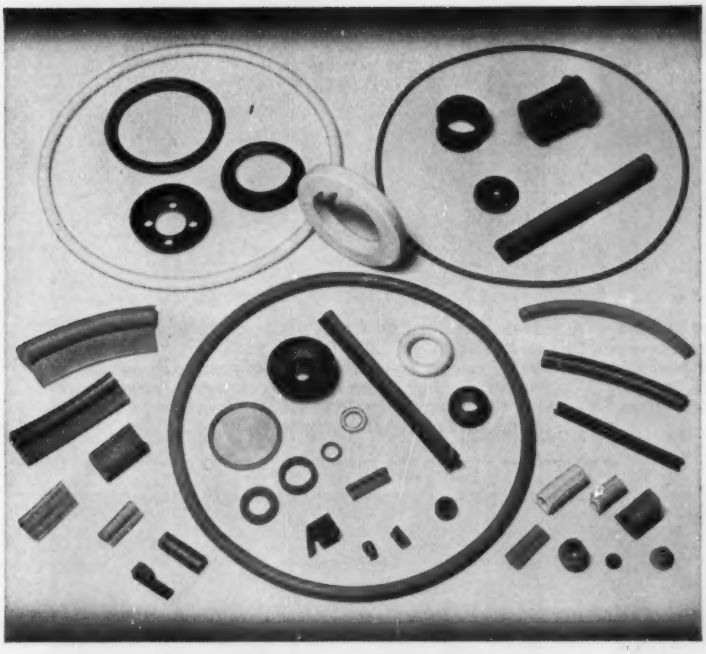

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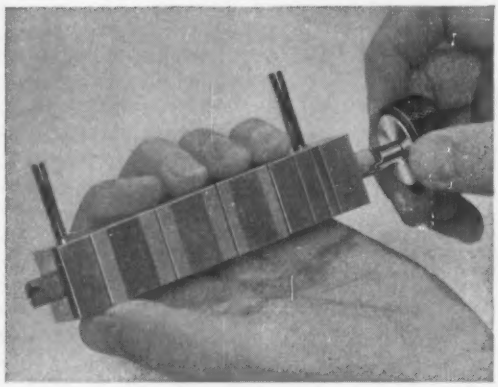

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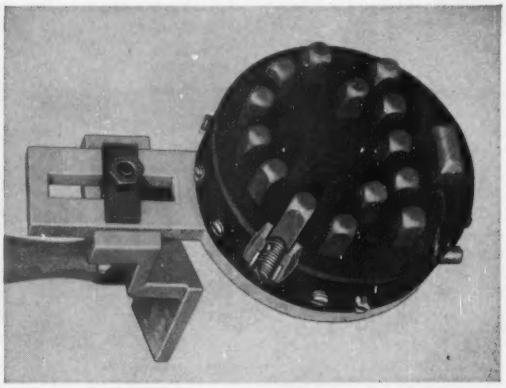

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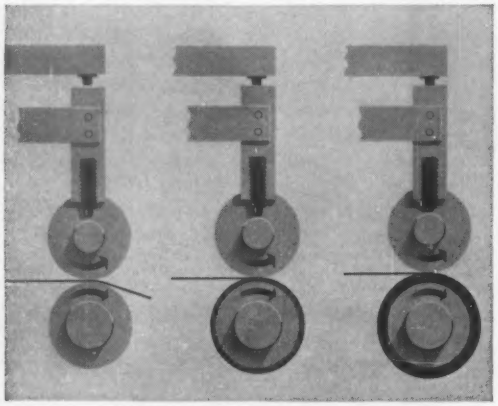

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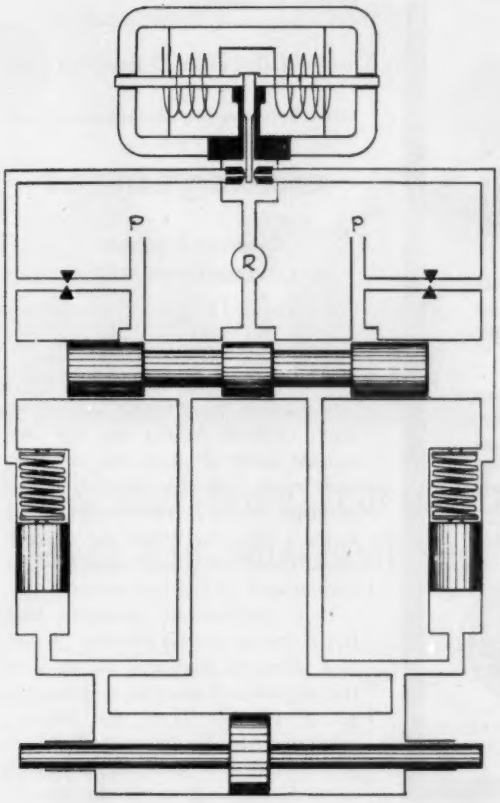

Fig. 5 — Electrohydraulic acceleration servovalve with pressure feedback.

of a hydraulic high-pass filter for which the effective time constant is about one-third of the load natural frequency. The filter consists simply of a spring loaded piston and orifice which are connected, respectively, in one of the load pressure feedback lines and between the pressure feedback connections to the valve spool.

One difficulty with this arrangement is that the hydraulic restriction must be a sharp edged orifice so that its characteristics will not vary with temperature. However, it has been found in practice that slight amounts of stiction in the load and actuator are sufficient to prevent undesirable limit-cycle oscillation from developing.

Load-pressure feedback can be effectively applied in a servo system by measuring the load pressure with electrical transducers and summing the resultant signal into the valve-driving amplifier. This technique provides maximum flexibility and convenient adjustment of the interacting gains in the pressure and position feedback loops.

A very recent and promising valve configuration to provide dynamic pressure feedback is shown in Fig. 5. This arrangement was developed primarily for mechanical simplicity. Here, the valve spool is still responsive to electrical input. However, the current is not producing proportional spool displacement but spool velocity. Essentially, this is an acceleration control servo with extremely small velocity tracking errors and infinite steady state load stiffness. No high-pass filter network is required on the pressure feedback.

The need for dynamic pressure feedback to provide damping may arise in a number of industrial applications. A common instance occurs on large machine tools where it is necessary to provide high velocity table drives over considerable travels. Because of the relative cost advantages over a hydraulic motor and lead screw, and because high table speeds are more easily achieved, direct cylinder drive is frequently used. The result is an extremely compliant coupling between the servovalve and the machine table. Low natural frequency limits the servo loop gain.

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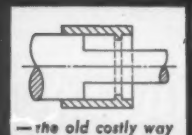

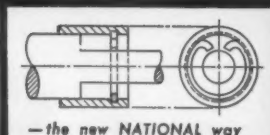

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Industrial Hydraulics, Chicago, Oct. 1960, 13 pp.

management

The Creative Engineer And Management Policies

Christopher E. Barthel Jr., Armour Research Foundation of Illinois Institute of Technology.

New information on the creative process and the creative individual. Each creative person has his own unique array of aptitudes, abilities, and traits, and this array is a fingerprint of his creativeness. Like anyone else, he reacts to external stimuli and can be encouraged or discouraged in his endeavors.

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NEC Paper No. 1356, "The Creative Engineer and Management Policies," presented at the 16th National Electronics Conference, Chicago, Oct., 1960, Proceedings pages 503 to 510.

Business and Technical Factors in Engineering

H. S. Dawson, manager-engineer, Electronic Equipment and Tube Dept., Canadian General Electric Co.

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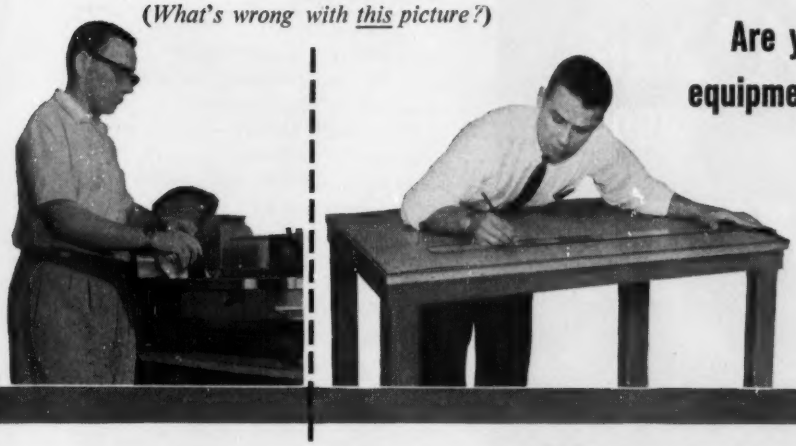

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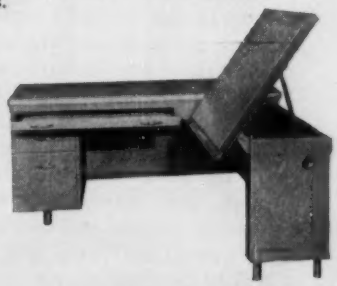

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NEC Paper No. 1358, *"The Need for Balanced Attention between Business Factors and Technical Factors in Engineering Work," presented at the* 16th *National Electronics Conference, Chicago, Oct.,* 1960, *Proceedings pages* 517 *to* 522.

mechanical

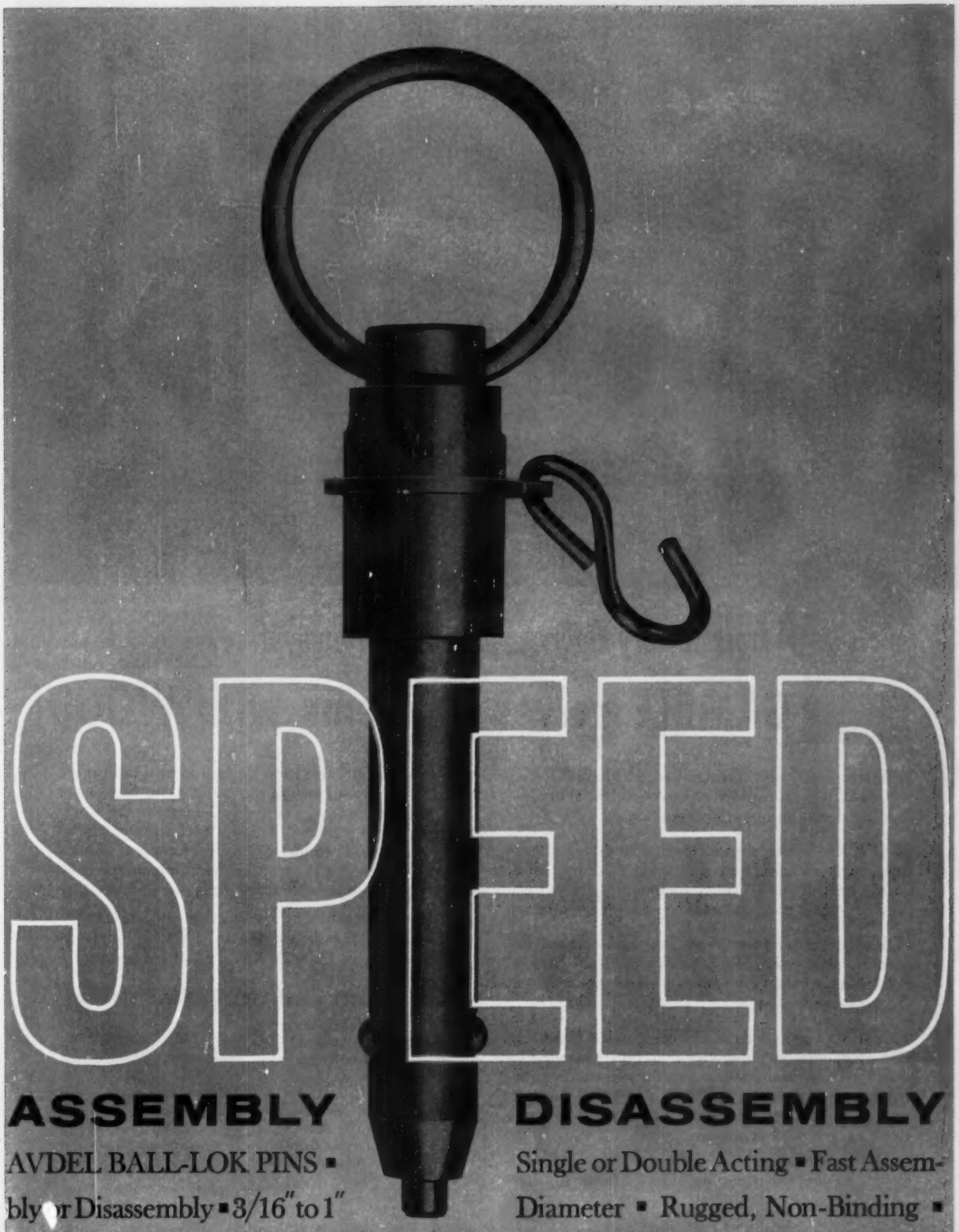
Design Considerations in a Magnetohydrodynamic Electrical Power Generator

G. W. Sutton, Missile & Space Vehicle Dept., General Electric Co., Philadelphia.

Essential factors in the design or application of a magnetohydrodynamic generator. Success depends upon sufficient electrical conductivity so that the generator length is reasonable. This requires high temperatures, 5000 F or better, with gases or vapors which will ionize easily. It is possible to decrease the generator length by increasing the magnetic field or decreasing the operating pressure. However, this is limited by the Hall effect. The following losses must be considered:

1. Exhaust temperature: The exit gases will be extremely hot—of the order of 4000 F. These gases must be utilized to obtain good cycle efficiencies. They may be used for such functions as propulsion, heat-power engines, or preheating the working fluid.
2. Entropy loss: The MHD flow is nonisentropic because of ohmic heating. It is found that 80 per cent, or better, equivalent turbine efficiencies are possible.
3. Magnet power: It is found that the fraction of power consumed by the magnet decreases as the MHD generator size is increased.
4. Wall cooling: To reduce the materials problem, some wall cooling may be possible with only a small loss of energy.
5. End losses: It is believed that end

Circle 505 on Page 19



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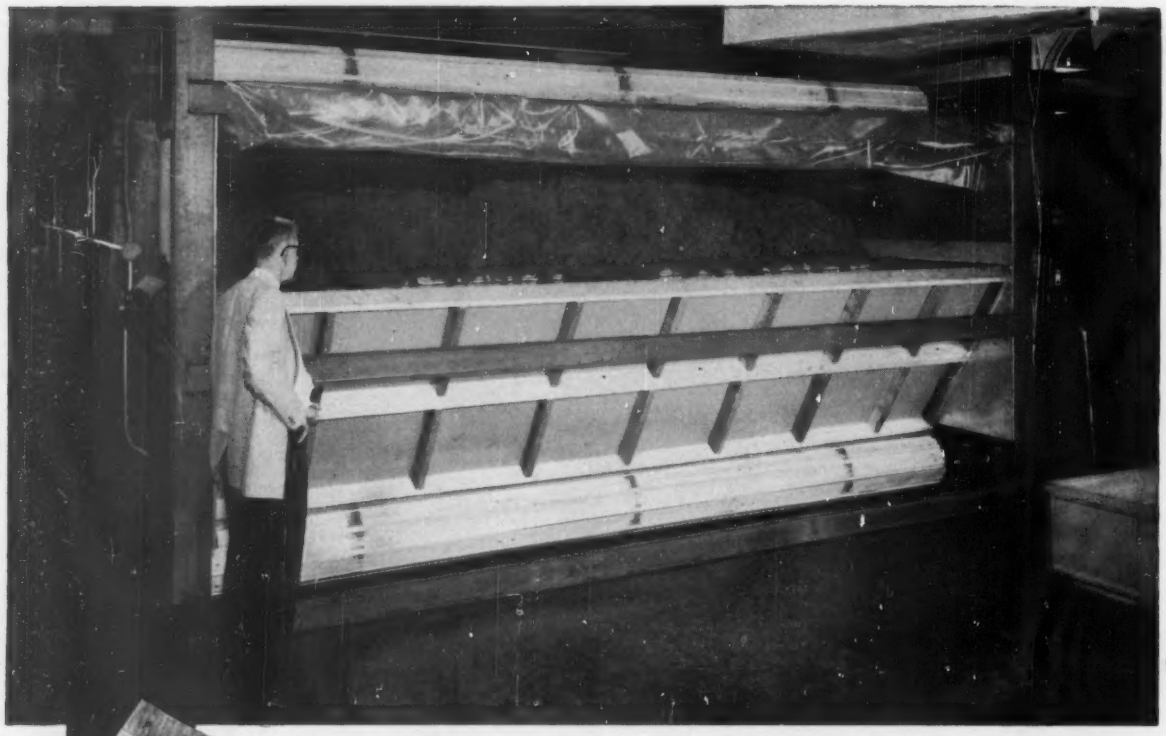

from factory floors...to tobacco conveyors...

GAMBLE solves problems with WOOD!

PROBLEM: Ordinary industrial wood block flooring was breaking up rapidly at heavy-traffic spots like loading docks, intersections, and aisles.

SOLUTION: Wood engineers at Gamble Brothers developed a laminated end-grain hickory block which lasts up to 10 times longer, despite punishing loads that quickly break up ordinary flooring.

PROBLEM: Tobacco conveyors required long orifice-forming slats whose dimensions would not change, even after use in a moisture-control operation in cigarette-making.

SOLUTION: Gamble Brothers designed a laminated slat of maximum dimensional stability, bonded by water-proof, heat-proof, non-taste-imparting adhesives. Our facilities enabled us to build the slats under environmental conditions identical to those to be experienced at end use.

Design problems like these are "all in a day's work" to the wood engineers at Gamble Brothers — a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design or component problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4619 Allmond Ave., Louisville, Ky.

If the problem involves wood, Gamble can help!

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GAMBLE BROTHERS, INC.

4619 Allmond Avenue, Louisville, Kentucky

losses can be controlled and reduced to a few per cent or less.

Since none of the above problems appear insurmountable, it should be possible to design a practical MHD generator.

SAE Paper No. 230F, "Design Considerations of a Magnetohydrodynamic Electrical Power Generator," presented at the SAE-AFOSR Astronautic Symposium, Los Angeles, Oct., 1960, 12 pp.

Plasma Dynamics

George I. Cohn, Illinois Institute of Technology.

This paper does three things: 1. It exemplifies various phenomena concerned with plasma dynamics. 2. It delineates the physical concepts and the ways in which their interrelationships are formulated to provide the basic equation from which the desired information can be extracted. 3. It outlines ways in which solutions can be obtained. The presentation ranges from the statistical mechanics of plasmas to the fully co-operative phenomena of magnetohydrodynamics and delineates how the phenomenological descriptions can be evolved from the microscopic view.

NEC Paper No. 1337, "Plasma Dynamics," presented at the 16th National Electronics Conference, Chicago, Oct. 1960, Proceedings pages 334 to 355.

Human and System Performance During Zero G

Edward L. Brown, Major, USAF, Air Force Ballistic Missile Div. (ARDC)

Observations and conclusions from two thousand flights in which zero g had been obtained for periods up to 15 sec. Areas investigated during zero g include:

1. Human performance on motors and mental tasks.
   a. Normal flying performance and procedures.
   b. Performance on actual emergencies.
   c. Human performance on experimental tasks.
2. Locomotion of individual humans inside large space vehicles.
3. Locomotion of individual humans outside space vehicles.
4. Human perceptive orientation.
5. Behavior of liquids.

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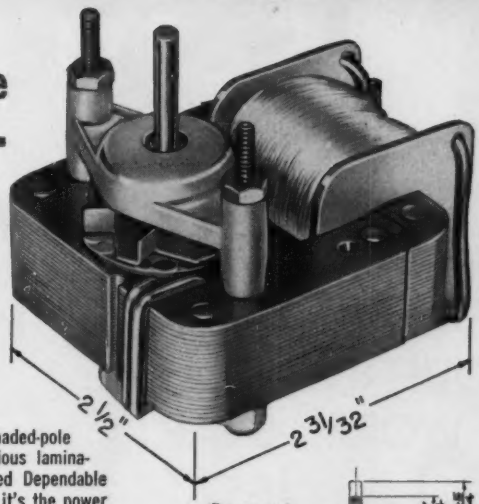
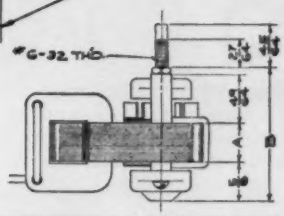


Model "A" Two-pole, shaded-pole motor available in various lamination thicknesses. Proved Dependable millions of times over, it's the power choice of the nation's great-name manufacturers . . . setting an amazing performance record in countless applications from phonographs to kitchen fans to pumps. If dependability is your aim, Model "A" is your motor!



MODEL	HP 3000 RPM	LOCKED TORQUE in./oz.	MAXIMUM TORQUE in./oz.	FREE SPEED RPM	AMPS FREE	WATTS FREE	A	B
A-3-CW A-3-CCW	1/500	0.7	1.1	3360	.275	10	3/8"	1 7/8"
A-4-CW A-4-CCW	1/350	1.0	1.4	3380	.375	14	1/2"	2"
A-5-CW A-5-CCW	1/180	1.7	2.7	3430	.460	17	5/8"	2 1/8"
A-6-CW A-6-CCW	1/130	1.9	3.3	3430	.500	19	3/4"	2 1/4"
A-7-CW A-7-CCW	1/100	2.1	3.8	3300	.530	20	7/8"	2 3/8"
A-8-CW A-8-CCW	1/90	2.5	4.5	3480	.550	23	1"	2 1/2"
A-9-CW A-9-CCW	1/70	2.7	5.3	3520	.620	27	1 1/8"	2 5/8"
A-12-CW A-12-CCW	1/60	3.0	6.5	3500	.720	28	1 1/2"	3"
A-14-CW A-14-CCW	1/50	3.1	7.0	3490	.730	33	1 3/4"	3 1/4"
A-16-CW A-16-CCW	1/45	4.0	7.5	3490	.730	39	2"	3 1/2"

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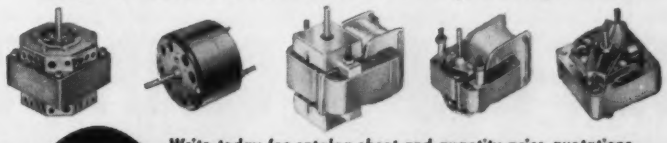

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Circle 508 on Page 19

Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD-66av.

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Ratchet • Screw
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6. Fluid transfer problems.
7. Heat transfer problems.

SAE Paper No. 230I, "Human and System Performance During Zero g," presented at the SAE-AFOSR Astronautic Symposium, Los Angeles, Oct., 1960, 5 pp.

What We Know About Space

E. N. Parker, Enrico Fermi Institute for Nuclear Studies, and Department of Physics, University of Chicago.

A bibliography and a brief review of the present status of interplanetary information. For the present, most knowledge is based on indirect inference.

SAE Paper No. 230Q, "Our Present Knowledge of Interplanetary Conditions," presented at the SAE-AFSOR Astronautic Symposium, Los Angeles, Oct., 1960, 5 pp.

materials

Tantalum Components In Microcircuitry

D. A. McLean, Bell Telephone Laboratories

Status of tantalum microcircuitry. The large number of components required by new and projected electronics systems create three urgent problems. Most important is reliability of components and interconnections. Second is the problem of size, and third that of cost.

Tantalum microcircuitry is being developed in an attempt to meet these problems. The process starts with formation of a tantalum pattern on an inorganic substrate. This pattern contains sub-patterns which represent resistors, capacitors, and interconnecting lines. The capacitor areas are anodized and counter electrodes added by evaporation. Thus, in one continuous pattern, the capacitor anodes, the resistors, and major interconnections are made. Metals other than tantalum are contenders for this type of circuitry.

The most successful substrates have been ones with smooth surfaces. Hence most of the work has been done on glass. Deposition is by sputering and electronic bombardment evaporation.

Tantalum microcircuitry should go far in solving the problems of reliability, size, and cost through sim-

Let a J-M friction specialist help you solve complex "stop and go" problems

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Circle 510 on Page 19

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Veeder-Root Electro-magnetic Counters provide new and simplified methods for count-rolling all types of plant operations.

These counters are actuated electrically by a variety of methods as shown above, making them completely flexible in application. These methods include non-contact probes and photo-cells, miniature switches and built-in "make and break" or standard contact switches. In addition, these electro-magnetic counters can be easily remoted — at any distance — to office locations or for centralized production control.

Send for complete information on Veeder-Root Electric Counters . . . Take advantage of the many new opportunities for improved and simplified counter application, possible only with this Veeder-Root line.

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VRD-98

plicity of processes and composition, structural homogeneity, and other important, features. Currently, transistors and diodes of conventional structure are plugged or soldered into place. In various organizations work is under way directed at producing active elements in packaging more suitable for microcircuitry use.

NEC Paper No. 1315, "Tantalum Components and Microcircuitry," presented at the 16th National Electronics Conference, Chicago, Oct. 1960, Proceedings pages 206 to 210.

electrical

Potential Capability of Light As an Information Carrier

Klaus W. Otten, Communication Laboratory, Wright Air Development Div.

Potential performance of communication systems at carrier frequencies throughout the electromagnetic radiation spectrum. Power required per cycle of information bandwidth is inversely proportional to the carrier frequency throughout the spectrum.

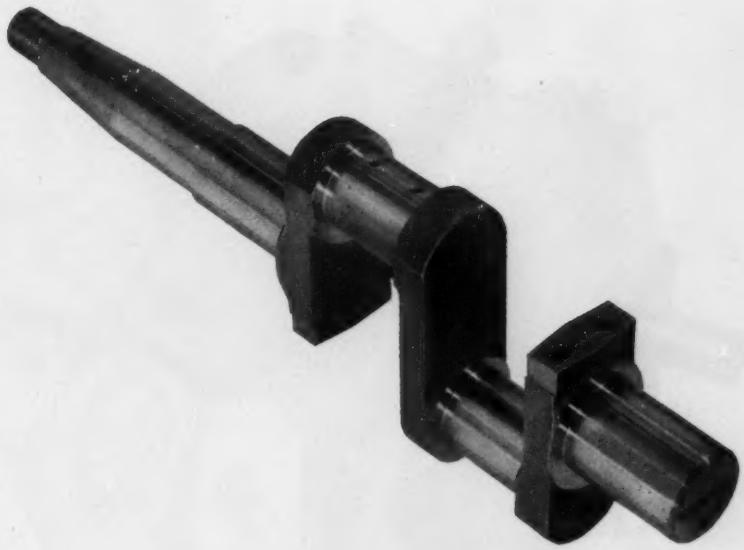
For all practical systems the power requirements are considerably higher. The increase in required power can be determined by certain specified factors which describe the deviation of the practical system from the ideal one. These factors, which are complex functions of frequency and other variables, cannot be expressed in a simple meaningful analytical form valid for the entire spectrum. For selected frequency bands, however, valid approximations can be made.

SAE Paper No. 230T, "Potential Capability of Light as Information Carrier for Space Communication," presented at the SAE-AFOSR Astronautic Symposium, Los Angeles, Oct., 1960, 14 pp.

Density of Interconnections In Miniature Circuits

R. G. Counihan, International Business Machines Corp., Federal Systems Div.

Problems and approaches in fabricating extremely dense interconnection networks. These include techniques for the multilayer vacuum deposition of conducting paths between miniaturized elements. The advantages of these techniques are that



RIGIDITY

A CASE IN POINT—This seventy pound ductile iron crankshaft is made for compressors manufactured by The Brunner Division of Dunham-Bush, Inc. The increased loads and speeds called for by new compressor design specifications required rigidity and strength beyond the limits of the cast iron alloy shafts formerly used. Ductile iron was chosen because the rigidity, tensile strength, fatigue strength and wear characteristics comfortably exceed operating requirements. A major bonus—the existing pattern equipment could be used for the ductile iron castings, thus saving the high cost of dies needed for steel forgings.

Ductile iron has most of the engineering advantages of steel yet it can be designed with the same flexibility and cast with the same procedures as gray iron. The 120-90-02 grade used in this case has an elastic modulus of about 24 x 10^6 psi, 42,000 psi endurance limit, and 300 BHN. The 120,000 psi tensile strength is double that of the previous crankshaft. Hamilton Foundry regularly casts all grades of ductile iron and high alloy Ductile Ni-Resist.

When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules —will be met.

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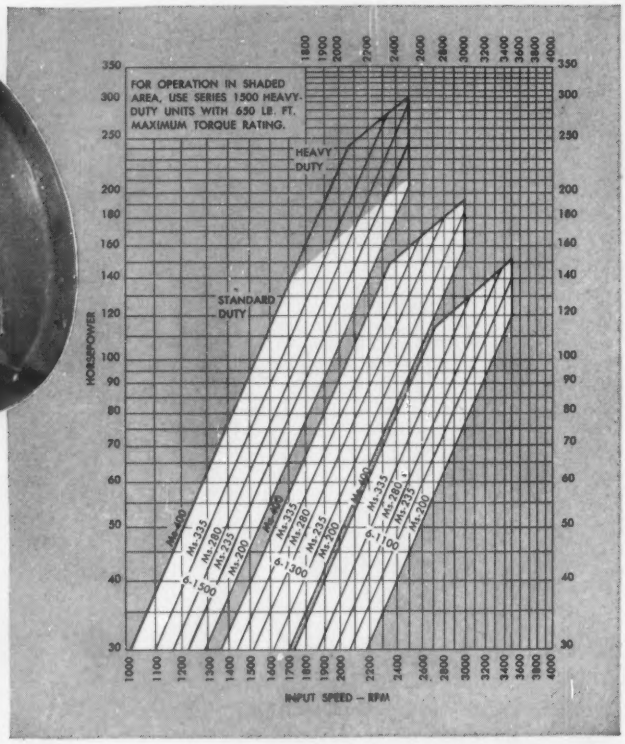
Circle 512 on Page 19

TWIN DISC

Torque Converters


FOR OPERATION IN SHADED AREA, USE SERIES 1500 HEAVY-DUTY UNITS WITH 650 LB. FT. MAXIMUM TORQUE RATING.
HEAVY DUTY
STANDARD DUTY
HORSEPOWER
INPUT SPEED – RPM

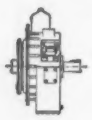
This chart gives horsepower and speed ratings for all Twin Disc Single-Stage Converters. Note that the 1500 Series is furnished in standard and heavy duty capacities. The figure "6" preceding the series number refers to the type of circuit.

"Stripped" or cartridge-type units for OEM in-line design

Nine models—11", 13" and 15" sizes.
Torque ratings from 235 to 650 lb.-ft.
Three types: Converter only; converter with oil-actuated disconnect clutch; and converter with disconnect clutch and lock-up direct drive clutch.

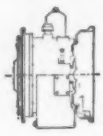
Basic power take-off units

Three models—13" and 15" sizes.
Torque ratings from 350 to 650 lb.-ft.
Suitable for side loads.



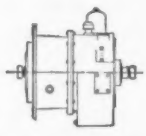
Spacer units for connection to transmissions

Three models—13" and 15" sizes.
Torque ratings from 350 to 650 lb.-ft.
Flanged output shaft.
Available with dummy flywheel for automotive type clutches.



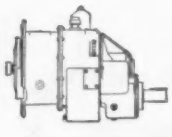
Units equipped with front-end disconnect clutch

Four models—13" and 15" sizes.
Single or double plate clutch.
Torque ratings from 350 to 650 lb.-ft.
Suitable for side loads.
Optional: Boom lowering freewheel for shovels and cranes.



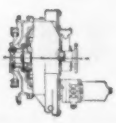
Units equipped with disconnect clutch plus 2:1 ratio reduction gear

Three models—13" and 15" sizes.
Single or double plate 11" clutch.
Torque ratings from 350 to 650 lb.-ft.
Suitable for side loads.
Optional: Boom lowering freewheel.



Sumpless PTO units for power-shift transmissions

Three models—13" and 15" sizes.
Live power take-off for auxiliary drives.
Torque ratings from 350 to 650 lb.-ft.
Flanged output shaft.
Optional: Rubber block input drive.



SINGLE-STAGE TORQUE CONVERTERS

25 models

Virtually any single-stage torque converter requirement can be met with one of Twin Disc's standard rotating-housing units. The scope of the Twin Disc line can be seen from the summarized listing at left.

Each converter size—11", 13" and 15"—has five interchangeable impellers which vary with respect to blade number and pitch so that each has a different torque absorption capacity. This exclusive Twin Disc design feature provides a 2:1 horsepower spread for each converter series. It insures correct matching of converter to engine and also permits a subsequent increase in engine horsepower without dimensional changes in the torque converter.

Twin Disc Single-Stage Converters are available as "industrial" (self-contained) units or as "stripped" (cartridge type) units for incorporation into OEM transmission designs. Complete details are contained in Bulletin 510. For your copy, write TWIN DISC CLUTCH COMPANY, Hydraulic Division, Rockford, Illinois.

Circle 513 on Page 19

first-level interconnections between circuits can be made with films as thin as one micron insulated by nonconducting films on the same order of thickness. Multiple levels of conducting paths are possible, all of which, with their associated insulators, can be deposited in a single pump-down of a vacuum system. In addition, this technique is directly compatible with the vacuum deposition of components. Key problem areas noted are vacuum technology, mask precision and registration, integrity of the insulating film, and topological considerations. Vacuum-deposited interconnections may satisfy most requirements.

NEC Paper No. 1314, *"Maximum Density Interconnections for Microminiaturized Circuitry," presented at the 16th National Electronics Conference, Chicago,* 1960, *Oct.,* 1960, *Proceedings pages* 199 *to* 205.

Thin Film Potential For Molecular Electronics

Eugene H. Miller, Electronic Technology Laboratory, Wright Air Development Div. Wright-Patterson Air Force Base

Problems involved in film circuitry and considerations in the selection of materials and processes.

Low-pressure deposition techniques have proven successful during the past 10 years in the development of new, improved, film-type electronic components and are now being investigated as a promising approach in the development of complete thin-film circuits. Low-pressure deposition techniques have exhibited good potentiality.

Circuitry formed by low-pressure deposition consists of depositing various electronic elements into thin films by such methods as vacuum evaporation or sputtering. Low-pressure deposition techniques for the synthesization of new solid structures to obtain preferred functional properties have been made attractive by the following capabilities: The capability of obtaining accurate control of film thickness down almost to molecular dimensions, the capability of being able to deposit a wide variety of materials from conductors to insulators, the capability of depositing materials free from atmospheric contamination, the capability of tailoring structures during

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hydraulic components

THE *heart* OF BETTER MACHINERY

Here are but a few of the many OEM'S and end users of RACINE EQUIPMENT that rely on its day-in, day-out dependability and performance superiority. You, too, can get the same sort of money-saving reliability from the equipment you use or produce by installing stout-hearted RACINE HYDRAULIC COMPONENTS.

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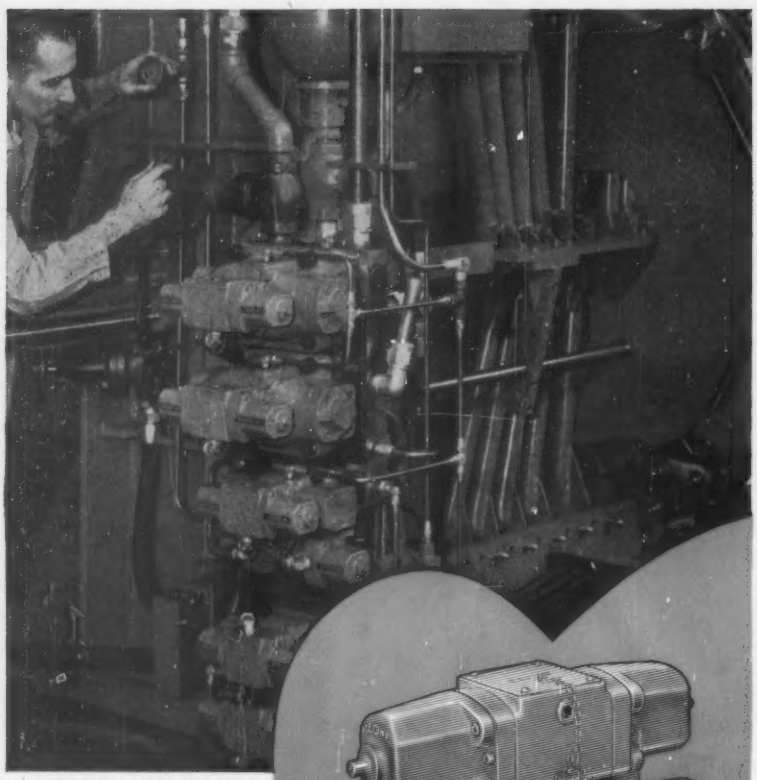
Circle 514 on Page 19

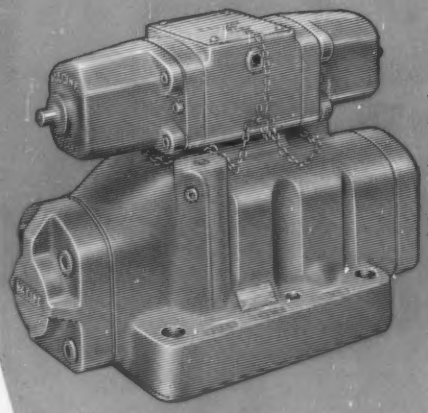


HYDRAULIC VALVE SYSTEM OF WIRE-FORMING MACHINE BUILT BY RESEARCH DESIGNING SERVICE, INC., CENTERLINE, MICHIGAN

during set-up and at 3000 springs per hour

RELIABLE VALVES DIRECT THE POWER OF A HYDRAULIC HEART

"Control of all our hydraulic operations is vital, and this is possible with RACINE equipment," says Bill Karolle, electrical engineer with Research Designing Service, Inc. "Our hydraulic machines are used to form wire for 80% of all automobile seat springs." As oil requirements change constantly during set-up operations, 6 RACINE DIRECTIONAL CONTROL VALVES guide the *right oil volume* at the *right pressure* to the *right place* at the *right time*. At high production speeds, these 4-way, solenoid-controlled valves maintain the pre-set wire forming pattern with absolutely uniform precision. Valve reliability is important since these machines may perform over five million cycles during their lifetime.



6 RACINE

Directional Control Valves guide hydraulic wire-forming operations of this machine

RACINE

Racine Hydraulics & Machinery, Inc.

RACINE, WISCONSIN

HYDRAULICS DIVISION

formation, and the capability of being able to produce electrical boundaries or junctions in a number of selected types of materials. More electronic functions per unit volume can be realized by the utilization of low-pressure deposition for the integration of electronic elements and for the development of new functional structures.

NEC Paper No. 1345, "Thin Film Potential to Molecular Electronics," presented at the 16th National Electronics Conference, Chicago, Oct., 1960, Proceedings pages 444 to 447.

Practical Considerations in Thin Circuit Microelectronics

J. M. Blank, I. A. Lesk, J. J. Suran, General Electric Co., Syracuse, N. Y.

Application of thin-circuit techniques to some logic functions, and their design, construction, and operation. The practical objectives of micro-systems electronics include size reduction, more efficient power utilization, increased reliability, and reduced cost. Also, any practical approach should have sufficient versatility for a wide variety of applications.

The thin circuit (2D, modular, substrate) approach holds more promise in satisfying all these objectives than any other presently proposed scheme. It allows a high degree of freedom in circuit design, the use of pretested components with close parameter control, and the use of different techniques for producing a wide variety of conductors, resistors and capacitors in place on the substrate.

The substrate is a thin wafer of any practical shape. The circuit components are laid down in an order determined by the processes used. High-value resistors and capacitors, as well as inductors, may be made and attached to the circuit separately.

Active components (transistors, diodes) are separately packaged in thin, miniature enclosures. Whenever possible, production devices are used to take maximum advantage of cost, tolerance, and reliability control obtainable only through large scale processes. Thus, the main difference between regular and microactive devices is the package.

Circle 515 on Page 19

Interconnections can be made reliably by careful control of soldering, thermocompression, ultrasonic bonding, or welding.

NEC Paper No. 1344, "Practical Considerations in Thin Film Microelectronics," presented at the 16th National Electronics Conference, Chicago, Oct., 1960, Proceedings pages 438 to 443.

techniques

Standard Languages For Data Processing

A. Craig Reynolds Jr., Stromberg Div. of General Time Corp.

The need for early standardization in the new technology of data processing. It seldom occurs that an art so new requires standardization so soon. The requirements have arisen primarily due to user pressure for compatibility of equipment.

The big problems are to establish standards for reliable communication between users and manufacturers, from humans to machines, from machines to humans, and from machines to machines.

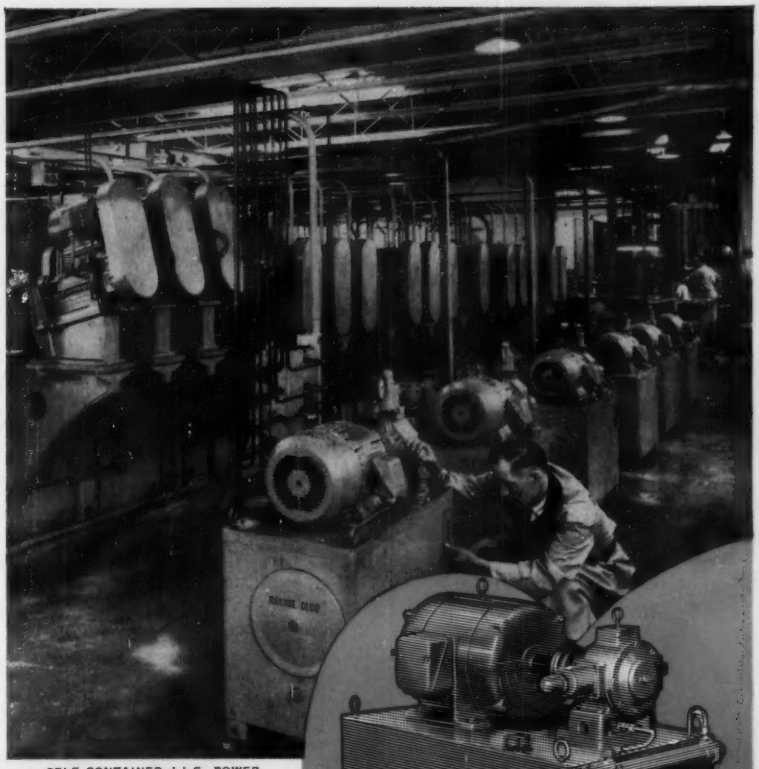
Throughout the problem, dollars are involved in several ways: First, the computer-communications ensemble is dealing with allocation and payment of costs for the procurement and use of men, material, and time. If these are to be mechanized, the highest order of reliability must be achieved. Second, the terminal equipments provided by the data processing industry must be economic for the user. Third, economic utilization of communications systems dictates a rapid rate of reliable data transmission.

ASA paper, "Communications and Languages in the Data Processing Field," presented at the Eleventh National Conference on Standards, New York, Oct., 1960, 9 pp.

Standards as Guides In Design and Development

G. J. Marks, staff specialist, Office of the Director of Defense Research and Engineering, Washington

Questions which can help to keep dynamic standards dynamic. When standards are dynamic, they reflect the current state of the art. They also provide a reliable and sensitive



SELF-CONTAINED J.I.C. POWER UNITS SERVING UNIVERSAL SPIDER TRANSFER MACHINE BUILT BY DRILLUNIT, INC., DETROIT

Six hydraulic hearts

FURNISH MUSCLE FOR 5 TRANSFER OPERATIONS . . . WITHOUT A PALLET

"This is the first time that a spider for a universal joint has been machined in direct transfer of the part itself rather than by pallet transfer," says William Defibaugh, Vice President and Chief Engineer of Drillunit, Inc. The new unit is only half the size of any previous spider transfer machine. Clamping and unclamping the spider are governed by 5 RACINE Model 4FA Pumps, each one a self-contained power unit with its own reservoir. A sixth 4FA unit controls movements which turn, probe and transfer the part from station to station. To complete the hydraulic package, 24 RACINE Model Q Pumps serve the standard self-contained drill units. R. S. Naeyaert, President, adds, "RACINE flexibility in delivering pressurized oil in *variable volume* at *varying pressures* make it the ideal choice."

The HEARTS of this automotive transfer operation are the compact RACINE *Power Units equipped with*

MODEL 4FA VARIABLE VOLUME VANE-TYPE PUMPS

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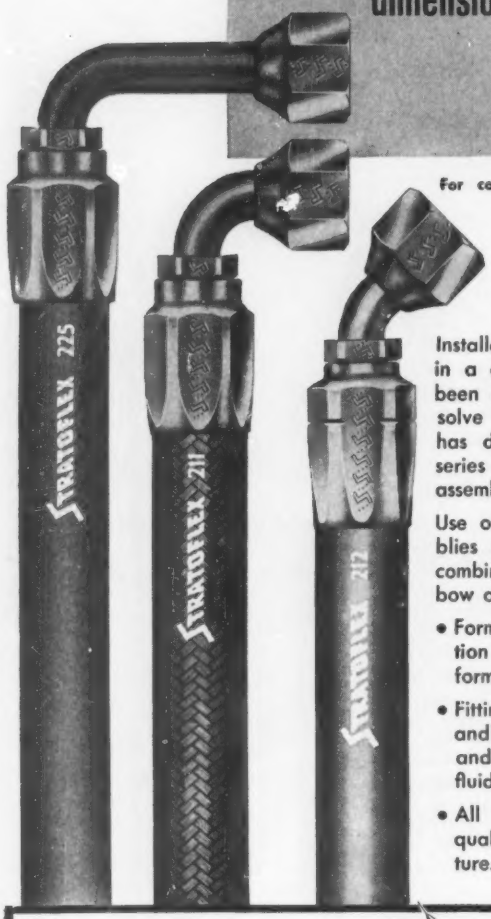
Circle 516 on Page 19

NOW AVAILABLE

STRATOFLEX

FLARED TUBE TYPE ELBOW FITTINGS AND ASSEMBLIES

For confined space installations where hose fittings of minimum dimensions are required



For complete information, write for Bulletin 5-4 today.

Installation of hose assemblies in a confined space has long been an industry problem. To solve this problem, Stratoflex has developed a flared tube series of elbow hose fittings and assemblies.

Use of these Stratoflex assemblies eliminates the need for combinations of fittings and elbow adapters.

- Form tubing used for fabrication of fittings to allow uniform flow.
- Fittings available for medium and high pressure applications and for transmission of all fluids.
- All fittings are quality steel, quality controlled in manufacture.

SFS-9

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San Francisco, Seattle
Toronto, Tulsa

indicator of the need for deeper research. The questions are:

What part does the designer play in deciding what additional engineering standards are most urgently needed?

If the design and development people are your customers, shouldn't they play a large part in determining what engineering guidance will best serve their purpose?

Are engineering standards of such quality that they afford the designer an opportunity to make an intelligent selection with a high degree of confidence?

Are standards timely—is the guidance available when the designer needs it or must he continually look elsewhere?

Do standards require an inordinate length of time to develop? If so, is it because co-ordinating procedures are time consuming, or is it because scope of coverage is too broad?

Are standards development interests more concerned with format than they are with the quality of technical content?

Does the make up of standard lend itself to ready revision of certain parts or must the whole standard be revised to bring a table up to date?

ASA paper, "Standards as Engineering Guidance in Design and Development," presented at the Eleventh National Conference on Standards, New York, Oct., 1960, 6 pp.

Engineering Documentation

William S. Hutchinson, assistant chief, Mechanical & Engineering Programs Branch, Standardization Div., Armed Forces Supply Support Center

The documentation program in the Department of Defense. Basic objective of the program, administered by the Standardization Div. of the Armed Forces Supply Support Center, is to provide adequate engineering data for the support of weapons and materiel required for defense. This involves:

Defining major problems.

Establishing detailed objectives.

Developing and approving plans, both immediate and long range, with project schedules.

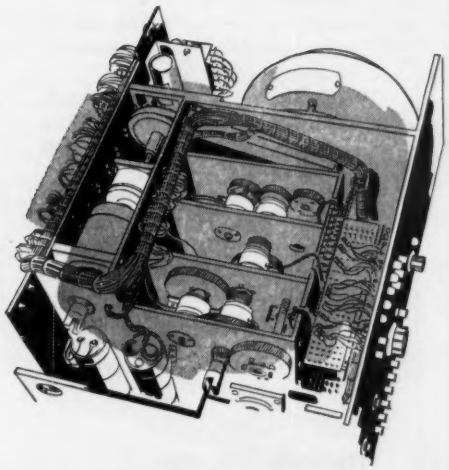
Authorizing and implementing programs.

Managing, appraising and controlling programs.

The problems are:

Determining the minimum military re-

Announcing A NEW LINE OF Fractional Horsepower ELECTRIC BRAKES and CLUTCHES

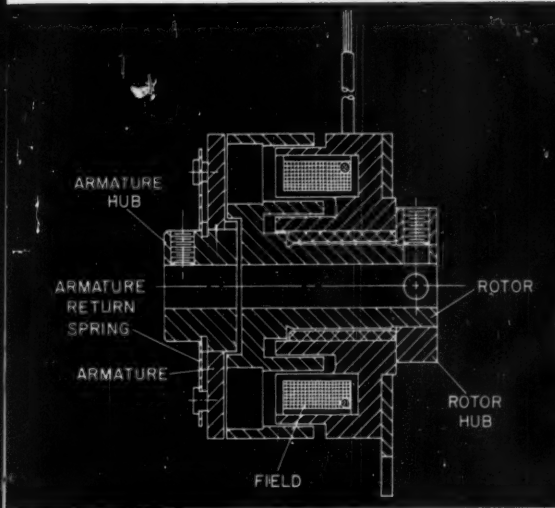


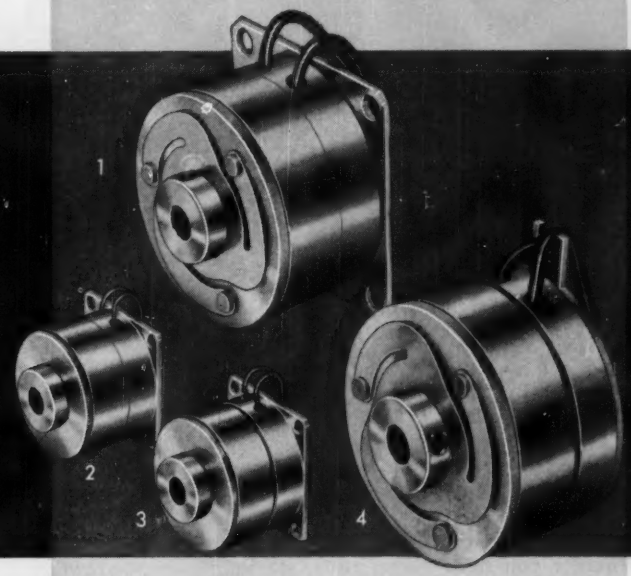
offering you —

HIGHER TORQUE PER UNIT SIZE THAN OTHER COMPARABLE MODELS

HIGH QUALITY AND PERFORMANCE AT LOW COST

These important advantages in both price and performance are the results of Haydon's manufacturing know-how — plus development and use of improved magnetic materials.





1 – 1.725" BRAKE
2 – .875" BRAKE
3 – .875" CLUTCH
4 – 1.725" CLUTCH

If you're now using mechanical brakes or clutches, Haydon makes the operating advantages of electrical types available, at a practical price. If you're already using electrical clutches or brakes, Haydon offers you improved performance plus substantial savings. Write today for data sheets.

Precision Haydon fractional horsepower electric brakes, clutches and clutch couplings are produced in two sizes: .875" diameter with 2 lb-in torque, and 1.725" diameter with 10 lb-in torque. Brakes and clutches are supplied at 28 volts or 90 volts standard. Control units are available. Additional sizes are under development and will soon be available.

TIMING MOTORS
TIME AND TORQUE CONTROLS

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DIVISION OF GENERAL TIME CORPORATION

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Circle 518 on Page 19

quirements for engineering documentation.

Improving adequacy, quantity, quality, and procedures for acquiring, storing and utilizing engineering data.

Adequately documenting military requirements, for the development and acquisition of engineering data.

Standardizing engineering data and associated procedures into the most useful documentation forms.

Developing capabilities for rapid search, retrieval, processing, and distribution of engineering data to promote wide utilization.

Establishing integrated DoD systems for managing engineering data assets that will provide for universal interchange of engineering information to promote multiple applications.

ASA paper, "Engineering Documentation," presented at the Eleventh National Conference on Standards, New York, Oct., 1960, 21 pp.

Standards Programs Aided by Computers

Dwight F. Hollingsworth, principal standards engineer, E. I. du Pont de Nemours & Co.

Data processing equipment as valuable tools in standards programs. Computers now do calculations, in support of standards work, which could not be justified, formerly, due to time and cost involved. In one example at du Pont, a computer calculated data for concentric plates used in measurement of fluid flow. An important condition in connection with computers is the lack of standardization in the publication of computer programs.

ASA paper, "Creating Standards Programs in New Areas," presented at the Eleventh National Conference on Standards," New York, Oct., 1960, 5 pp.

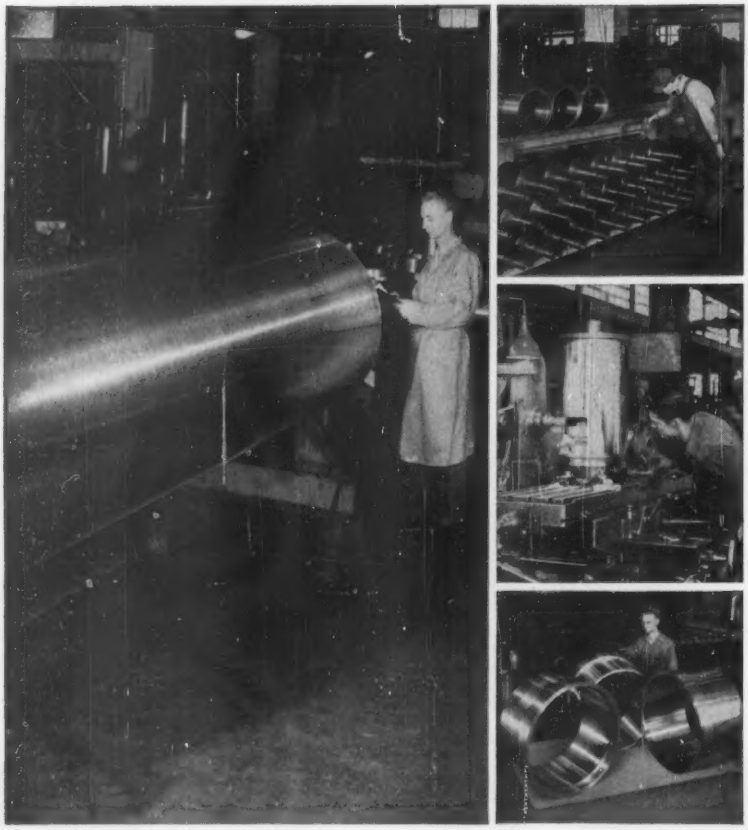
TO OBTAIN COPIES of papers or articles abstracted here, write directly to:

ASA—American Standards Association, 10 East 40th St., New York 16, N. Y., papers 50 cents each, 11th National Conference Proceedings, $4.50.

NCIH—National Conference on Industrial Hydraulics, sponsored by Illinois Institute of Technology, 3300 South Federal St., Chicago 16, Ill., Vol. XIV, Conference Proceedings, 6 dollars each.

NEC—National Electronics Conference Inc., 228 North LaSalle St., Chicago, Ill., Vol. 16, 1960 Proceedings, 6 dollars each.

SAE—Society of Automotive Engineers, 485 Lexington Ave., New York 17, N. Y., papers 50 cents to members, 75 cents to nonmembers.



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WHATEVER the inside or outside pressures, Shenango centrifugal castings are better able to withstand them without failure.

Parts cast by the Shenango centrifugal process are much tougher because their finer, *pressure-dense* grain avoids stress concentrations while providing greater strength, better elongation and freedom from such costly defects as sand inclusions, blowholes and such.

Whether you need rings, rolls, sleeves, liners, bushings, bearings, mandrels or *any* annular or symmetrical part . . . ferrous or non-ferrous . . . in whatever shape, size or dimension to meet your requirements . . . Shenango can do the job. And do the job *better!*

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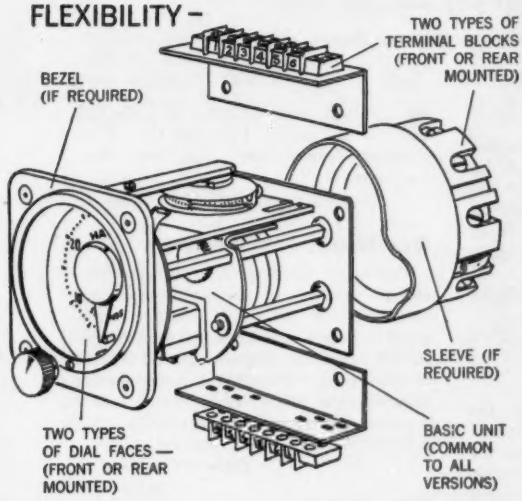
NEW External Clutch Reset ACROTIMER

FLEXIBILITY –


TWO TYPES OF TERMINAL BLOCKS (FRONT OR REAR MOUNTED)
BEZEL (IF REQUIRED)
SLEEVE (IF REQUIRED)
TWO TYPES OF DIAL FACES — (FRONT OR REAR MOUNTED)
BASIC UNIT (COMMON TO ALL VERSIONS)

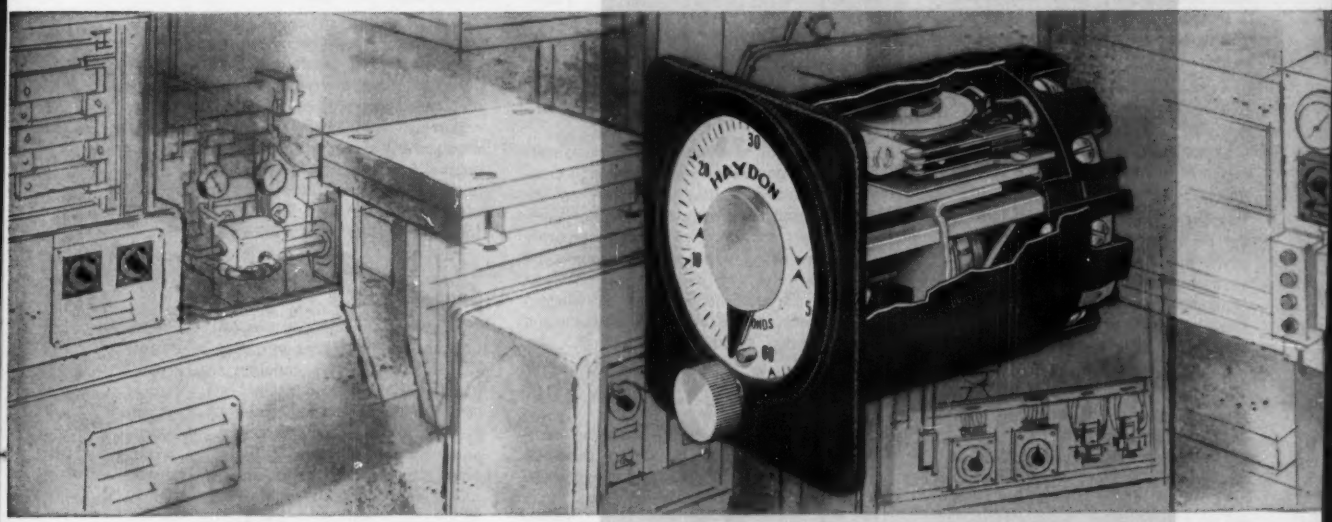
Provides time delay or interval timing, opening or closing one or more switches after an adjustable period of time — and, in addition, offers you these advantages.

EXCEPTIONAL VERSATILITY . . . results from modular construction concept. One basic unit plus easily assembled standard parts provides 12 different variations to meet a very wide range of physical and electrical requirements. Reduces cost, speeds deliveries.

LOWER COST . . . than other units of comparable capacity and quality, because of savings made possible by advanced design and modular construction.

SIMPLE CONSTRUCTION . . . with fewer moving parts. This means greater dependability and contributes to lower purchase price without sacrificing quality and performance.

COMPACT . . . ½" shorter than the next smallest competitive unit and 1" smaller than most competitive units.



Supplied for rear or panel mounting, the ACROTIMER line is designed for operation at 120 to 240 vac, 50 or 60 cycles. Adjustable time ranges from 6 seconds to 4 hours are available. For complete information on these timers, write today for your free copy of the new Haydon ACROTIMER Catalog.

HIGHER RATED LOAD SWITCHES . . . with your choice of one 15-amp or two 10-amp switches.

SPRING-TYPE CLUTCH . . . means negligible wear; longer life; and faster, more positive engagement.

TIMING MOTORS
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Circle 520 on Page 19

"the HITCHINER way..."

...and non-machinable super alloys in INVESTMENT CASTING

These spray nozzles for highway striping paint sprayers were formerly machined out of cold rolled bar stock. When ordinary paint was used, these nozzles functioned satisfactorily. However, when ground glass was added to the paint for reflecting purposes excessive wear caused frequent replacement.

By "the HITCHINER way . . .", we were able to engineer the manufacture of this part by investment casting in a non-machinable type alloy exhibiting a very high degree of resistance to both wear and corrosion.

This change of alloy, which eliminated the need for frequent nozzle replacement, was made possible through investment casting because the required close dimensional tolerances and detail could be cast to size.

Through the wide freedom of choice in alloy, as well as through flexibility in design and the elimination of expensive machining operations, investment casting may possibly solve your metal parts manufacturing problems. Send us your sample or blueprint and find out with a Hitchiner "engineered quotation" — no obligation.

NO LIMITATIONS. From miniature ball bearing races to 20" Steam Turbine Impellers, "the Hitchiner way . . ." with investment castings can help you.

Send for our latest revised brochure and find out for yourself. It's free.

HITCHINER
MILFORD 19, NEW HAMPSHIRE
Coast to Coast Engineering Representatives

Circle 521 on Page 19

Helpful Literature for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Speed Reducer

New catalog describes step-function speed Reductor in detail, and includes seven individual case studies of new designs based on this principle. Reductor provides ten separate ratios from 1:1 to 1000:1 in single unit, desired ratio easily selected by turning a dial. About 10 pages. Insco Co., Div., Barry Wright Corp., Main Street, Groton, Mass.

Circle 701 on Page 19

Clamps and Couplings

Pocket-sized Catalog 99 contains information on a complete line of instrument clamps and precision couplings for all mechanical and electrical applications. Dimensional drawings and tables present all engineering specifications. 48 pages. Siamco Corp. Div., Tech-Ohm Electronics, 36-11 33rd St., Long Island City 6, N. Y.

Circle 702 on Page 19

Pressure Switches

New catalog contains descriptive sheets on Dual-Snap pressure switches. General information is given first on the switches and their special features. Various models are then described on separate sheets, including photographs, dimensional drawings, and list of specifications and features. Approximately 12 pages. Custom Component Switches Inc., 3137 Kenwood St., Burbank, Calif.

Circle 703 on Page 19

Precision Gears

Pocket-sized Catalog 22 contains complete specifications, detailed drawings, and prices on high-performance Spiroid worms and gears. Design advantages of the units are pointed out. Tables provide complete size information. 24 pages. PIC Design Corp., 477 Atlantic Ave., East Rockaway, L. I., N. Y.

Circle 704 on Page 19

Glass-Steel Material

New full-color Bulletin 985 details steps in manufacture, physical and chemical properties, and end use of Glasteel. Two pages are devoted to general physical characteristics, especially to the nature of the physical and chemical bond existing at glass-steel interface. Information on types of Glasteel available for varying service conditions is presented in table form. Technical data section includes discussion of operating temperatures, thermal shock, heat transfer, testing facilities, and resistance to acids and alkalies. 20 pages. Pfaudler Co., Div., Pfaudler Permutit Inc., 1124 West Ave., Rochester, N. Y.

Circle 705 on Page 19

Wire-Wound Potentiometers

Two-color Catalog 101 outlines percision wire-wound potentiometers and turns-counting dials. It contains complete technical specifications and dimensioned mounting diagrams for all models of the units. Photographs, engineering drawings, and tables furnish specifications. 6 pages. Spectrol Electronics Corp., 1704 S. Del Mar Ave., San Gabriel, Calif.

Circle 706 on Page 19

Miniature Lamps

Pocket-sized Bulletin 1106-R gives complete specifications of many specially engineered lamps. It contains dimensional drawings, data on range of voltages, current capacities, and light output on lamps engineered and produced for use in instrumentation, computers, electronic equipment, surgical instruments, and other highly specialized functions. 8 pages. Chicago Miniature Lamp Works, Dept. MD-1, 1500 N. Ogden Ave., Chicago 10, Ill.

Circle 707 on Page 19

Gear Pumps

Descriptive Bulletin 10-150.1 covers pressure-balanced gear pumps available in 72, 92, and 112-gpm capacity at 112 rpm, 0 psi. Cutaway drawing is used to point out important features. Tables and graph provide data on specifications, performance, and selection. Modifications available are also listed. 4 pages. Hydreco Div., New York Air Brake Co., 9000 E. Michigan, Kalamazoo, Mich.

Circle 708 on Page 19

Electronic, Electrical Products

Condensed electronic-electrical product reference guide points up the most frequently ordered products. It fits easily into a desk file or three-ring binder. Booklet covers ratings and other essential technical data on variable transformers, automatic voltage regulators, electrical connectors, binding posts, dual electrical connectors, synchronous motors, packaged transformer primaries, decade line correctors, loading reactors, and power supplies. Tables, drawings, and photographs are included. Superior Electric Co., Dept. PG, 83 Laurel St., Bristol, Conn.

Circle 709 on Page 19

Microwave Tube File

Speci-File is a painted 4 x 6-in. metal file box which has one card devoted to each tube in the company's line. Information on the card comprises a complete electronic and physical biography of the tube. File is comprehensively indexed to aid in rapid location of tubes and transfer of data to engineering work sheets. Cards are sorted and indexed according to frequency band, and are color-coded to show function of each tube. Sperry Electronic Tube Div., Sperry Rand Corp., Gainesville, Fla.

Circle 710 on Page 19

Industrial Hose

Bulletin 627 serves as a guide for proper hose selection, listing 112 separate liquids and gases to be carried. Suitability of various tubestocks for use in carrying these agents is charted in excellent, good, conditional, and unsatisfactory categories. Separate chart provides fundamental information about pressure, temperature, and size limits of individual hose types. 12 pages. Aeroquip Corp., Jackson, Mich.

Circle 711 on Page 19

Lock Nuts

Catalog 592-A describes and illustrates complete line of spring-tempered steel lock nuts, including regular hex, integral washer, acorn, wing, and adjusting nut types. It gives details of design and locking principle, advantages, typical applications, specifications, load ratings, materials and finishes. Booklet incorporates many photographs, drawings, and tables. 24 pages. Palnut Co., 75-L Glen Rd., Mountainside, N. J.

Circle 712 on Page 19

Pump Controls

Integrated control systems for aircraft and missile variable-displacement hydraulic pumps are described in Bulletin A-5259. Five special control systems are covered: Electrically depressurized, constant horsepower, load sensitive, dual range, and servo. Curves illustrating typical regulation characteristics of each type are presented. Specifications on both fixed-angle and yoke-type variable-displacement pumps are included. 4 pages. Vickers Inc., Div., Sperry Rand Corp., Detroit 32, Mich.

Circle 713 on Page 19

Cast-Tooth Sprockets

Stock sizes of cast-tooth sprockets are conveniently listed in Book 2867. Cast-tooth sprocket teeth are ground to fit the chain, and selection data are based on this relationship. These are 132 different chain numbers listed and cross-referenced to 48 sprocket lists. Complete range of types and sizes, considering many modifications, permits selection from over 30,000 stock sprockets. 12 pages. Link-Belt Co., Dept. PR, Prudential Plaza, Chicago 1, Ill.

Circle 714 on Page 19

A new shaft seal to handle the most corrosive service conditions has been recently added to the John Crane line. Here's a seal that will stand up under all conditions of acids and salts, oxidizing agents and organic compounds.

It is so designed that all parts that normally contact the fluid are made of chemically-inert DuPont Teflon. Also, for this same reason it can be operated over wide temperature range up to 250° F.

Mechanically, its bellows type construction readily adapts it for use in all non-abrasive slurry applications. It also compensates for extreme shaft run out.

Available in single face construction for internal or external mounting, double face for internal mounting.

Full range of shaft sizes from ⅝" to 3".

Get Complete Details

Request Bulletin S-233
Crane Packing Company
6425 Oakton Street
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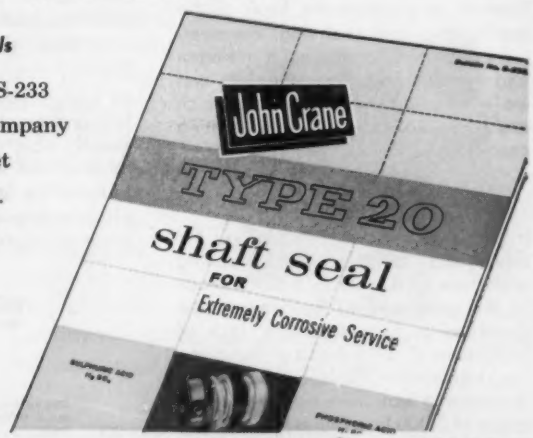
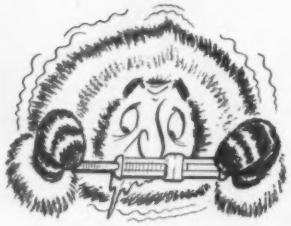


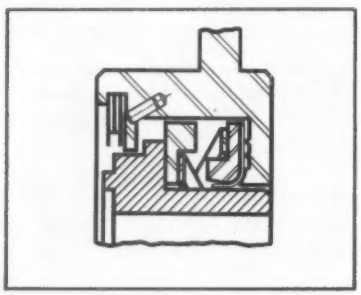
Circle 522 on Page 19

Secrets of Successful Seal Design

Cryogenics - No. 2 of a Series



The sealing of very cold liquids with mechanical seals has opened a new dimension in cryogenics — and, with it, new problems. For instance, many mechanical seals which are satisfactory for liquid oxygen service at –280°F may lose one-half or more of their service life when used with liquid nitrogen at –320°F.



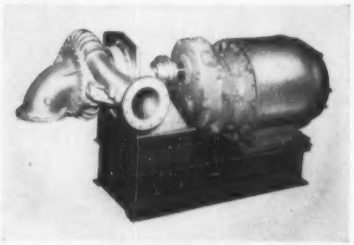
Sealol LOX Seal — *thin film, Kel-F* packing .005" thick, replaces the customary O-ring or V-cup packing, thus reducing axial drag caused by elastomer shrinkage.*

Liquid oxygen, or LOX, is probably the simplest of the cryogenics to handle since it appears to supply some small amount of lubrication, perhaps in the form of an oxide on the faces of the mating ring and seal ring. However, lubrication values of liquid nitrogen and hydrogen are practically nil, and we must select face materials which are designed for "dry" operating conditions.

**TM Minnesota Mining & Mfg. Co.*

HOT OR COLD

It is curious how our technology for solving high temperature, dry-running seals now unexpectedly finds a place at the other end of the temperature spectrum. In both situations, lack of lubrication is at the heart of the problem. Incidentally, our specially treated dry-running seals have met life requirements of 3,000 hours on a shaft turning at 7,000 RPM, ambient temperatures to 250°F and intermittent pressures to 650 psi when water was pumped for two minutes once every four hours.



Equipped with standard Sealol LOX Seal, *this 500 GPM centrifugal pump is part of skid-mounted LOX ground support equipment manufactured by the Cambridge Division of Standard Steel Corporation. Discharge pressure is 100 psig max., 2380 RPM operating speed.*

SEAL LOCATION

Pump design and general operating conditions will have a lot to do with seal performance when handling cryogenics. Provide, if you can, for the seal to operate directly in the liquid being sealed. This will give you the benefit of whatever lubrication value the fluid has, plus better heat transfer conditions, and is usually preferable to sealing the gases themselves. When the seal is operating in the vapor stage, the temperatures ambient to the seal are usually slightly higher than if the seal were immersed in the fluid.

APPLICATION REQUIREMENTS

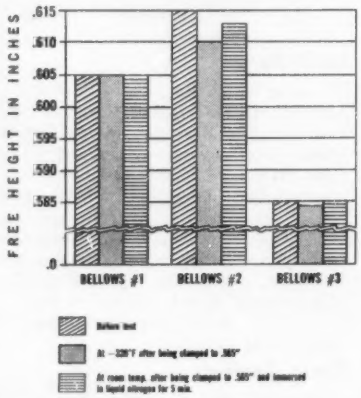
Our missile customers usually think of seal life in terms of minutes and seconds, or at the most, in hours. On the other hand, our industrial customers want LOX transfer pump seals to stand up for years. In the latter case, speeds and pressures are considerably lower, and under favorable conditions, a life of 1,000 hours is certain.

At high rubbing speeds, say 10,000 fpm and more, "burn" marks are frequently observed on the rubbing surfaces of the seal and mating rings in spite of the fact that the temperature of the cryogenic being sealed is hundreds of degrees below zero.

High spring loads will frequently be the villain behind this curious phenomenon. Seal designers have been leaning towards higher spring loads in order to overcome the drag caused by stiffening of the elastomers at low temperatures. If you notice burn marks on your mating rings, check for excessive spring loading in relation to face rubbing speeds.

BELLOWS SEALS

Sealol balanced-pressure bellows seals, on the other hand, provide a positive answer to this problem because metal bellows offer no temperature induced resistance to axial movements as do elastomers. As a result, spring loads can be reduced to any level consistant with optimum face loading.



Cold-soak tests *have indicated that bellows spring characteristics (Stainless #300 Series Steel) remain unchanged for all practical purposes, before, during and after immersion in cryogenic liquids.*

We have learned the hard way that there are no pat answers to problems involving cryogenics, because each requires special consideration. We'd be glad to exchange information and, if you wish, submit a proposal for your specific problem.

SEALOL

INC.

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Houston — Greenwood 2-2318
Los Angeles — Chapman 5-3746
San Francisco — Fireside 1-8130

In Europe: Sealol-Europe s.a.r.l.
79 Boulevard Gallieni, Issy-Les Moulineaux, Seine, France

Adhesives Selection

Bulletin A-100 is a selector chart which shows the outstanding properties of certain adhesives and hardeners. It gives tensile shear strengths at different temperatures and in several fuels. Operating temperature range, izod impact, and numerous other criteria are indicated. Guide fits into three-ring binders or makes an easy-reference wall chart. Adhesives Dept., Hysol Corp., Olean, N. Y.

Circle 715 on Page 19

Induction Motors

Bulletin 600C covers squirrel-cage induction motors in basic dripproof designs. It outlines squirrel-cage motor applications, performance characteristics of the motors, mechanical design variations, construction details, insulation details, ratings, and dimensions. Many tables, cutaway views, and curves are provided. 12 pages. Century Electric Co., 18th & Pine Streets, St. Louis 3, Mo.

Circle 716 on Page 19

Cold-Headed Fasteners

Illustrations by product groups of parts and fasteners, plus cold-heading design information are contained in Bulletin S-100. Shown under headings of rivets, nails, threaded parts, and double-headed parts are cold-headed specialty items. All metals are available, with any plating, coating, or finish. 4 pages. John Hassall Inc., Box SF, Westbury, L. I., N. Y.

Circle 717 on Page 19

Hose Fittings

New 21 x 32-in. two-color wall chart provides ready-reference data for all reusable hydraulic hose, couplings, and fittings. Illustrations of all items are given, showing dimensional and other data. Chart enables fluid-power users easily to find the catalog numbers of the reusable products shown. Anchor Coupling Co. Inc., 342 N. Fourth St., Libertyville, Ill.

Circle 718 on Page 19

Universal Connectors

Technical Bulletin C10 provides data on connectors for fast, solderless installation. Unit is pictured, and features are discussed. Various connector bodies are shown in drawings, and dimensional drawings are also presented. Contacts for the connectors are shown, with tables giving engineering data. 4 pages. Industrial Systems Div., Hughes Aircraft Co., P. O. Box 90904, Airport Station, Los Angeles 45, Calif.

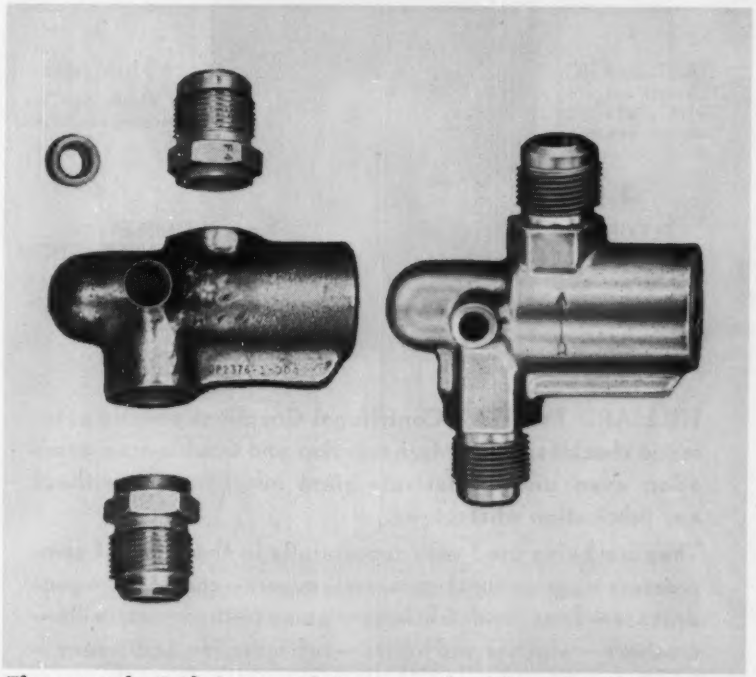
Circle 719 on Page 19

Fluid Motors

Bulletin PP5 provides specifications, photographs, and dimensional drawings for British-built five and seven-cylinder Staffa hydraulic motors. Motors offer very high torque and low variable speeds, eliminating gearboxes. Performance curves are also included. 4 pages. Double A Products Co., Manchester, Mich.

Circle 720 on Page 19

FOUR PARTS REDUCED TO ONE
—A BRIDGEPORT CORED FORGING STORY



The one-stroke Bridgeport cored forging on the right replaced the four-part casting assembly on the left.

The purpose of these valves is to control liquid under pressure. The four-part assembly shown on the left did not operate to fullest efficiency. Leakage frequently was present because of the porosity in the part's cast element.

The Engineering Staff at Bridgeport's Cored Forging Division designed the economical one-piece cored forging pictured on the right to abolish – once and for all – the leakage problem as well as many of the production steps.

The control valve is now all one unit. Assembly time has been eliminated and inspection time and part porosity are things of the past. Good, positive chucking for threading operations has reduced machining time to the necessary minimum. This simple, yet significant achievement, is an example of what Bridgeport's forging processes, both die and cored, can do for your component or part. Learn more about Bridgeport's forging facilities.

Write to Dept. 8912 for your copy of our detailed 16-page brochure, "Bridgeport Forgings."

CORED FORGING DIVISION
BRIDGEPORT BRASS COMPANY
1000 Connecticut Ave., So. Norwalk, Conn.
Specialists in Metals from Aluminum to Zirconium

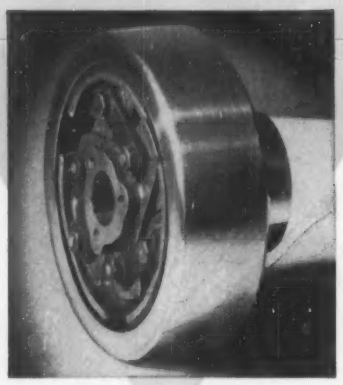
Circle 524 on Page 19

CLUTCHES FOR POWER CONTROL DESIGNS

THE NEW HILLIARD-TWIFLEX
Centrifugal Coupling

1
AUTOMATIC
smooth starting with protection against overload shock.

2
FLEXIBLE
in all directions without any loose joints.



3
ADJUSTABLE
to exactly suit the operating conditions.

4
SIMPLE CONSTRUCTION
and easy assembly even in blind installations.

HILLIARD-TWIFLEX Centrifugal Couplings provide automatic shockless power transmission and trouble-free operation even under relatively great misalignment without any lubrication whatsoever.

They are being used very successfully in the drive of compressors—agricultural sprayers—mixers—conveyors—generators—fans and blowers—pumps—hammer mills—crushers—winches and hoists—refrigeration equipment—textile machinery—and wherever smooth, efficient operation is needed.

Tests in a variety of installations for over five years prove the Twiflex is the practical solution to many drive problems.

WRITE TODAY FOR BULLETIN CE-3 WITH COMPLETE INFORMATION.

★ CONSIDER AUTOMATION-INVESTIGATE THESE PRODUCTS

• OTHER HILLIARD CLUTCHES •

SINGLE REVOLUTION CLUTCHES for automatic accurate control—electrical or mechanical—or intermittent motion, indexing, cycling and cut-off. Ask for Bulletin 239.

OVER-RUNNING CLUTCHES for automatic instantaneous engagement and release on two speed drives, dual drives and ratchet or backstop action. Ask for Bulletin 231.

SLIP CLUTCHES for overload protection, or constant torque and to provide constant tension and permit speed variation on rewind stands. Ask for Bulletin 300.

THE HILLIARD Corporation
MANUFACTURING CLUTCHES FOR OVER 50 YEARS

103 W. FOURTH ST., ELMIRA, N. Y.

IN CANADA: UPTON • BRADEEN • JAMES, LTD.

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

DC Power Supplies

Bulletin GED-4184 discusses new line of precision-regulated, transistorized, dc power supplies for a variety of applications in the utility, industrial, military, and electronics areas. It explains features of the line of 30 standard units. Publication contains photographs and charts showing guaranteed specifications of each of the model. 8 pages. General Electric Co., Schenectady 5, N. Y.

Circle 721 on Page 19

Clutches and Brakes

New brochure provides information on Electromic dry-particle clutches and brakes. Data on performance characteristics, mechanical specifications, and environmental specifications are included. Curves, graphs, and dimensional drawings illustrate these data. 4 pages. Technology Instrument Corp., 531 Main St., Acton, Mass.

Circle 722 on Page 19

Cap Screws

Self-locking Kapscrews—hex-head, 12-point, and internal-wrenching types—are described in new bulletin. Large drawing shows how the screw works, and special features are pointed out. List of applications is included. 4 pages. Klincher Kapscrew Inc., 2153 Hillside Ave., Indianapolis 18, Ind.

Circle 723 on Page 19

Torque Actuator

Bulletin 266013 illustrates and describes new midget Rotac torque actuator. Unit uses hydraulic or pneumatic pressure to produce rotary reciprocating movements. Midget models are used for light applications in instruments, computers, switches, and to operate small valves. Folder includes complete descriptive information, mounting drawing, and engineering data. 4 pages. Greenville Plant, Ex-Cell-O Corp., 945 E. Sater St., Greenville, Ohio.

Circle 724 on Page 19

Adjustable-Speed Drive

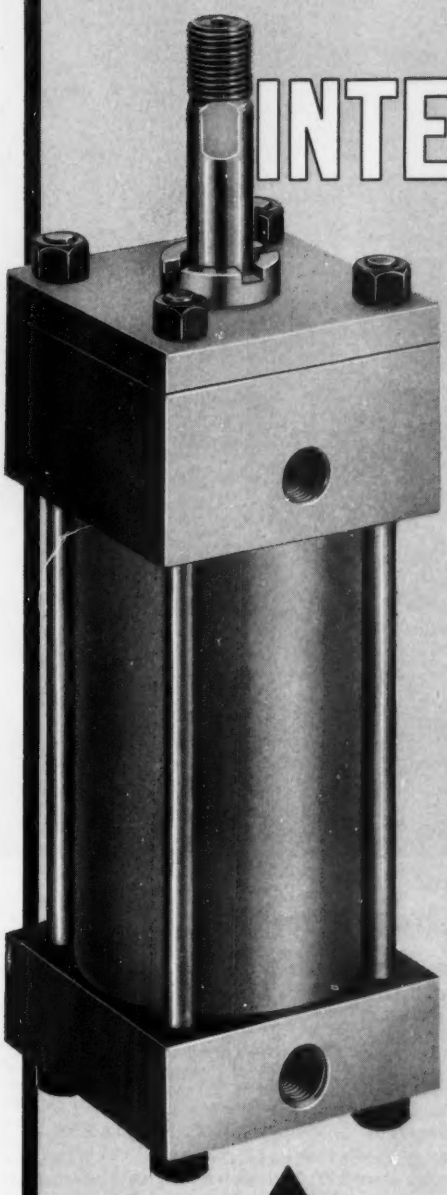
Information on where and how to use an infinite-range, adjustable-speed drive of high accuracy is given in Bulletin 551. Principles of operation are shown. Special controls for a wide variety of speed-control systems are described, and complete ratings and dimensions are given. 8 pages. Graham Transmissions Inc., Menomonee Falls, Wis.

Circle 725 on Page 19

Heavy-Duty Transmissions

Designed for heavy industrial applications, transmissions are described in new bulletin. Picture of each unit is given, along with engineering data and typical applications. Advantages of the units are pointed out. Transmission variables such as rotation, location, speed, shifting, and mounting are detailed. 8 pages. Cotta Transmission Co., 2300 Eleventh St., Rockford, Ill.

Circle 726 on Page 19



NEW INTERCHANGEABLE CYLINDER

For 250 psi air to 2,500 psi oil applications, Alkon's new Series B cylinder has

PREMIUM FEATURES

including case-hardened, high-tensile piston rod, chrome-plated steel barrel, quick-change piloted packing cartridge, nylon piston bearing, floating cushion. The Series B is designed for increased cycle life, higher efficiency, reduced maintenance —all at an

ECONOMY PRICE

that is the result of imaginative "production-engineering". Because of manufacturing economies, the new Series B cylinder, like its popular low-priced companion cylinder, the Series D, contains more premium features per dollar than any cylinder made today! You save on initial purchases, you save throughout the long, trouble-free life of the cylinder.

Most Models Are Available From Stock in bore sizes from 1½" through 6".

Write today for this new 24-page catalog on Alkon cylinders, valves and drill units!

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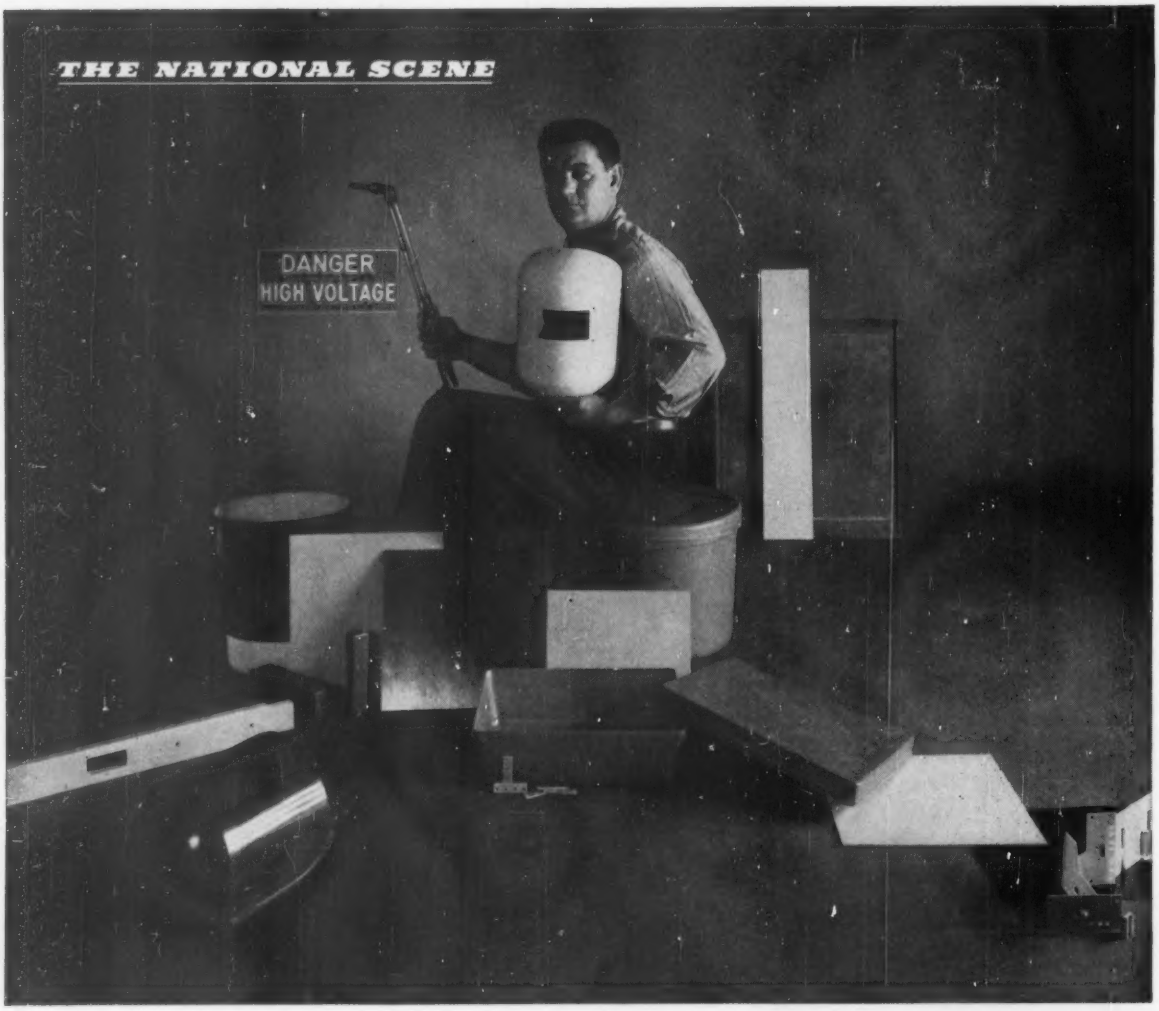

"YOUR NEXT POLYESTER COMPONENT: mold it or machine it?"

Get an unbiased answer from National because we work either way

Giving the designer facts to help make the *right* design decision faster is perhaps our best "product." Offering the broadest line of plastic materials and services permits us to give impartial help. Take polyester glass mat.

If the facts about configuration, volume, performance, operating conditions and cost point to a *molded* polyester shape, we'll work from scratch—or from your drawings—and deliver 100% usable parts.

If the same facts point to a *machined* part, we'll work the same way . . . and with the same results. In this case National can furnish four standard grades from which to select the one best material. GP-9100-A is our general purpose, medium cost sheet with good electrical and mechanical properties. GP-9104 is also general purpose, but lower cost. GP-9202 is our flame resistant grade and best electrical grade except for arc resistance. GP-9204 is both flame *and* arc resistant, UL-approved for sole support of current carrying parts at temperatures up to 150°C.

One more point. The problems inherent in machining polyester glass laminates have had a tendency to discourage some designers from considering it. We suggest that you bounce this headache out of your production facilities and into ours.

You see, we are interested in *both* your design and machining problems. Your component will be skillfully machined at one of our four complete, "service-located" fabricating facilities.

Send for our Polyester Technical Bulletin 1164. We'll be happy to include, also, data on the full line of National materials—over 100 grades. Write to National Vulcanized Fibre Co., Dept. G-12, Wilmington 99, Delaware.

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WILMINGTON 99, DELAWARE
In Canada:
NATIONAL FIBRE CO OF CANADA, LTD., Toronto 3, Ontario

Circle 526 on Page 19

CHOOSE FROM THESE MATERIALS...

Vulcanized Fibre: 10 standard grades; many special grades.

PHENOLITE® Laminated Plastic: over 80 standard and modified grades; paper, cotton fabric, nylon, asbestos, glass fabric, cotton and glass mat bases; phenolic, melamine, polyester, epoxy or silicone resins.

PEERLESS Electrical Insulation: coil, strip, corrugated.

Extruded Nylon: 2 grades; rod, strip, pressure tubing, special shapes.

Polyester Glass Mat: 4 standard sheet grades; custom molded shapes.

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Combination Materials: Rubber-PHENOLITE; Rubber-Fibre; Wood-Fibre; Metal-Fibre; Asbestos-Fibre; PEERLESS-PHENOLITE.

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Magnetic Drives

Bulletin TP-1-60 provides information on Tormag magnetic drives, pointing out features and explaining construction and operation. Typical applications and problems solved by use of the drives are provided. Engineering selection information is given, including torque versus slip speed curves. Tables and dimensional drawings are also included. 12 pages. Tormag Products Div., Gleason Reel Corp., 740 N. Plankinton Ave., Milwaukee 3, Wis.

Circle 727 on Page 19

Synchros and Resolvers

New condensed catalog lists over 100 standard MIL-S and high-accuracy units available. Arranged by function, the frame size, type number, government designation, frequency, voltage rating, accuracy, applicable MIL spec, and outline drawings are given for each. Location of detailed electrical, mechanical, and performance characteristics is speeded by indexing specific catalog pages for each unit. 4 pages. Vernitron Corp., 125 Old Country Rd., Carle Place, L. I., N. Y.

Circle 728 on Page 19

Tachometers

Catalog 62 contains photographs, drawings, and descriptions of 19 distinct types of tachometers. It also includes drawings of several types of flexible shafts and drives, and drawings of various drive arrangements. Catalog should be of interest to those having problems of speed measurement, production control, or quality control. 12 pages. Jones Motrola Corp., 432 Fairfield Ave., Stamford, Conn.

Circle 729 on Page 19

Tube Fittings

Form TF-1060, with illustrated specification tables, details a line of tube fittings, accessories, and typical applications. Featured is the O-Ring Seal line, with cutaway illustrations and descriptions of adaptability in typical, difficult design or maintenance situations. 22 pages. Lenz Co., 3301 Klepinger Rd., Dayton 1, Ohio.

Circle 730 on Page 19

Custom Gears

Bulletin pictures a variety of gears made for several applications in fine and extra-fine pitches. Table of gear-tooth parts is included. 4 pages. Beaver Gear Works Inc., 1025 Parmele St., Rockford, Ill.

Circle 731 on Page 19

Ball Valve

New ball valve is described and detailed in Circular 611. It details the operation of the valve, showing cutaway views, and giving ratings. Specific design features are described, and information on dimensions is included. Applications and advantages are discussed. 2 pages. Lunkenheimer Co., Box 360, Cincinnati 14, Ohio.

Circle 732 on Page 19

Industrial Series 1000 — External rings
Industrial Series 2000 — External rings
Industrial Series 3000 — Internal rings
Industrial Series 3100 — External rings

INDUSTRIAL RETAINING RINGS cut costs, simplify assembly

Precision-engineered INDUSTRIAL Retaining Rings ... internal, external and open types ... are available in a wide selection of sizes and finishes. Solve your fastening problems simply and economically with the rings that cut machining and tooling expense, save material, simplify and speed assembly.

Series 1000 and 2000 are available *stacked* for quickest application.

Write for free ring samples and catalog.

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Circle 527 on Page 19

FELT
BY FELTERS

PROVIDES DEPENDABLE,
LOW-COST PARTS FOR

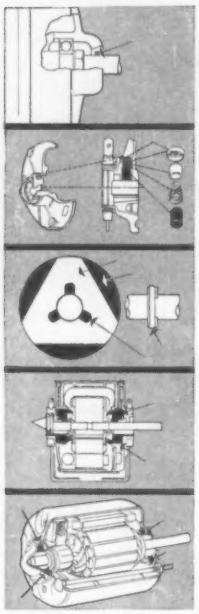
ELECTRIC MOTORS

Seals . . . wicks . . . lubricators . . . washers . . . gaskets — are all vital electric motor parts that benefit from Felt by Felters.

A special Felters' "Engineered Fabrication" processes felt to specific thickness, density, hardness, and resiliency; and provides special characteristics such as absorption, stiffness, water repellency and flameproofing.

And, new felt and plastic laminates, called PlastiFelts, use synthetics such as Nylon, Teflon, Hycar and rubber to provide an even wider range of application, plus greatly improved performance.

These are some of the many electric motor applications where Felt by Felters offers both a low-cost and high performance material for non-metallic parts.



Felt seal inserted around shaft opening retains grease and keeps out foreign matter.

This self-oiler uses a felt wick, bearing against the shaft under spring pressure, for constant lubrication.

This is a thrust washer designed for double duty as a lubricator by the use of a felt ring and lubricating notches.

Lifetime bearing lubrication is possible by selection of correct SAE grade, and designing into sealed bearing.

Felters' "Engineered Fabrication" makes it possible to specify felt shapes for a complete motor and shaft lubricating system, combining reservoirs, and wicking, and directing oil flow to all required areas.

To get the most out of Felt, send for the Felters Design Book — a complete digest on properties and applications. Write, today.

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Pioneer Producers of Felt and Synthetic Non-Woven Fabrics M.D.-6

HELPFUL LITERATURE

Induction Motors

Design features, performance characteristics, and size range of redesigned squirrel-cage induction motors are described in Bulletin 6100.1. Designed to increase motor life under severe operating conditions, Multiguard stator encapsulation and open protected construction make the motor impervious to water, acid, abrasion, and both mechanical and electrical abuse. 8 pages. Lincoln Electric Co., 22801 St. Clair Ave., Cleveland 17, Ohio.

Circle 733 on Page 19

Miniature Blowers

Bulletin 540 describes VAX-3-BD miniature vaneaxial dc blowers. Features are pointed out, and dimensional drawing is provided. Two graphs provide data on typical performance. 2 pages. Globe Industries Inc., 1784 Stanley Ave., Dayton 4, Ohio.

Circle 734 on Page 19

Subminiature Switch

Data Sheet 180 covers highly sensitive 11SM401 subminiature switch designed for use where close control sensitivity or response is mandatory. Switch features a 0.001-in. differential travel which makes it suitable for temperature or pressure control in military, electronics, and instrumentation fields. Sheet includes mounting dimensions, operating characteristics, electrical rating, and pricing information. Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle 735 on Page 19

Shaft, Flange-Mounted Drives

Bulletin 7100 provides information on shaft and flange-mounted drives. Material includes design and construction, use, selection, dimensions, accessories, motor mount, oushings, sheave and belt selection, NEMA motor information, and typical installations. Many dimensional drawings and tables are included. 36 pages. Falk Corp., Milwaukee 1, Wis.

Circle 736 on Page 19

Porous-Metal Process

Bulletin describes a new process to obtain controlled porosity in stainless steel, iron-nickel alloys, and other high-temperature metals. Range of properties obtainable and applications are given. 4 pages. Mott Metallurgical Corp., 272 Huyshope Ave., Hartford, Conn.

Circle 737 on Page 19

Belting

Form 1347 describes BostRon hazard-proof belting, giving all advantages and providing construction data. Tables present information on design properties, minimum pulley diameters, selection of belt covers, weight and thickness, and ply selection. 8 pages. Boston Woven Hose & Rubber Div., American Biltrite Rubber Co., Boston 3, Mass.

Circle 738 on Page 19

Circle 528 on Page 19

Circle 529 on Page 19→

your map in a **UNIVERSE** of AIRCRAFT PUMPS

This new engineering bulletin leads you right to the hydraulic pump designs you may be looking for. Here, passing on parade, are high performance gear pumps made to the measure of the next generation in aircraft, missiles, spacecraft, and support equipment.

Many of these units are the product of ready-made, mass-produced components that can be teamed into the precise configuration you need. Custom-designed pumps are also available.

All have in common these classic Eastern hydraulic pump characteristics:

SMALL SIZE: Eastern gear pumps are the smallest, lightest made. Airborne servo system pump shown delivers 1.5 gpm @ 1500 psig — measures only 1⅞" x 1⅞" x 2¾", weighs 9 oz.

WIDE PERFORMANCE RANGE: pumps available have theoretical displacement from .0016 to 1.30 cu. in. per revolution — flow from .025 to 9.6 gpm, pressures from 0 to 2000 psig, at speeds to 24,000 rpm. Weights with motor range from 1.5 to 8.5 lbs.

UNAFFECTED BY EXTREME ENVIRONMENTS: rugged, reliable Eastern units take loads to 50g in stride — shrug off temperature differentials to meet MIL specs.

Other Eastern products:
- **hydraulic motors**
- **servovalves, amplifiers, actuators and systems**
- **pressurization/dehydration packs**
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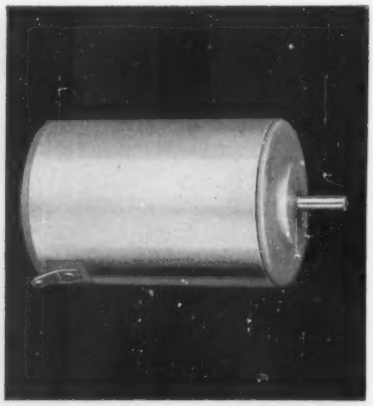
Barber-Colman quality battery-operated d-c motors with integral governors ideal for many of today's portable applications



BYQM-Typical Specifications

Voltage range	approx. 3 to 30
Governed speed	approx. 1200 to 6000 rpm
Torque	0 to .20 oz-in.
Maximum dia	1.29"

HYQM-Typical Specifications

Voltage range	4.5 to 30 volts
Governed speed	1500 to 5000 rpm
Torque	0 to .20 oz-in.
Maximum dia	1"

THE MARK OF QUALITY

BARBER COLMAN

d-c small motors

TYPE BYQM, above left, is inexpensive, yet of excellent quality to meet consumer demand for dependability in mass-produced goods. Its high efficiency results in low current drain, longer battery life. Integral governor features exceptionally stable characteristics. Rugged, self-aligning bearings.

TYPE HYQM, above right, is an exceptionally fine-quality battery-operated motor for the more demanding applications such as certain portable instruments and marine navigation equipment. Integral governor has adjustable stationary contact. Square brushes with optimum pressure over entire useful life. Self-aligning sintered bronze or R1 ball bearings. Ambient temperature maximum, 200° F.

typical applications:

PORTABLE DICTATING MACHINES
PHOTOGRAPHIC EQUIPMENT DRIVE MECHANISMS
TAPE PLAYERS
ROTATING BEACONS
DEPTH FINDERS
BLOWERS
PORTABLE INSTRUMENTS
ROTISSERIES

WRITE FOR HELPFUL DATA SHEETS on BYQM and HYQM battery-operated motors specifically designed to fit individual customer applications.

BARBER-COLMAN COMPANY

Dept. L, 1873 Rock Street, Rockford, Illinois

Circle 530 on Page 19

HELPFUL LITERATURE

Gear Reducer Selector

Quick-Selector is available as an aid to designers, engineers, purchasing agents, and distributors in seeking the right model Radicon fan-cooled worm-gear reducer. Shirt-pocket selector automatically gives the correct model for any combination of input speed, ratio or output speed, and required capacity. It also gives 20 key dimensions for the selected unit. Foote Bros. Gear & Machine Corp., Dept. MJ, 4545 S. Western Blvd., Chicago 9, Ill.

Circle 739 on Page 19

Multiple-Speed Drives

New master manual provides data on multiple-speed transmissions. Much general information is included, as well as specific catalog data on various models available. Selection tables are provided for the units, as well as price information. About 50 pages. Turner Uni-Drive Co., 3416 Terrace St., Kansas City 11, Mo.

Circle 740 on Page 19

Self-Adhesive Materials

New brochure describes self-adhesive Mylar-vinyl laminates for decorative trim. Included are performance specifications and samples. Swatches affixed to the brochure are included as an aid to designers. These include 17 different types of patterns and finishes. 4 pages. Fasson Products Div., Avery Adhesive Products Inc., Dept. 99, 250 Chester St., Painesville, Ohio.

Circle 741 on Page 19

Hydraulic Gear Pump

Brochure describes new motor-driven hydraulic gear pump with integral relief valve, check valve, and reservoir combined as a single unit. Power package is pictured, and tables provide pertinent engineering data. Dimensional drawing is also included. 2 pages. Wooster Div., Borg-Warner Corp., Old Mansfield Rd., Wooster, Ohio.

Circle 742 on Page 19

Pressure Gages

Catalog 305 provides information on various types of pressure gages for general industrial use. Units are pictured in photographs and line drawings, and all dimensions and pertinent data are included. 16 pages. United States Gauge Div., American Machine & Metals Inc., Sellersville, Pa.

Circle 743 on Page 19

Metal Spherical Powders

New process for producing spherical powders of metals and metal alloys in sizes from 5 to 150 microns is described in Form 1402. Physical data on the powders are outlined in the bulletin, along with material on suggested applications, and information on price and delivery. 8 pages. Linde Co. Div., Union Carbide Corp., 270 Park Ave., New York 17, N. Y.

Circle 744 on Page 19

Solenoid Selection Slide

Slide chart assures selection of correct Double T solenoid for any given commercial or industrial application. Basic setting is desired length of solenoid stroke, calibrated from 0 to 1⅜ in. Once length of stroke is set, pull in pounds and current draws in amperes can be read for various voltages in each constant and intermittent-duty solenoid. Solenoid can then be selected which best meets pull requirements. Industrial & Commercial Controls Dept., Controls Co. of America, 9555 Soreng Ave., Schiller Park, Ill.

Circle 745 on Page 19

Permanent Magnets

Catalog describing hundreds of Alnico permanent magnets is now available. Book provides handy reference material for the selection of cast or sintered Alnico magnets for a variety of uses. Technical data includes magnetic and mechanical properties and tolerance information. Terry Sales Corp., 1041 Silver Beach Rd., Riviera Beach, Fla.

Circle 746 on Page 19

Plastic Moldings

Brochure 200 on plastic moldings covers basic cold-molded compositions and hot-molded formulations developed to reduce size requirements for electrical moldings. Bulletin outlines the history of the development of Rosite, a stonelike molding compound which possesses properties making it desirable for electrical applications. General information on the various Rosite formulations, comprehensive list of applications, and photographs illustrating complexity of moldings are provided. 8 pages. Rostone Corp., 2401 S. Concord Rd., Lafayette, Ind.

Circle 747 on Page 19

Pneumatic Controllers

Catalog J-C describes pneumatic pressure and temperature controllers which control pressures to 10,000 psi and temperatures from −125 to +1000 F. Catalog describes features and accessories, and gives dimensions, specifications, materials of construction, and complete engineering information. Data on when to use a controller are also included. 6 pages. OPW-Jordan, 6013 Wiehe Rd., Cincinnati 13, Ohio.

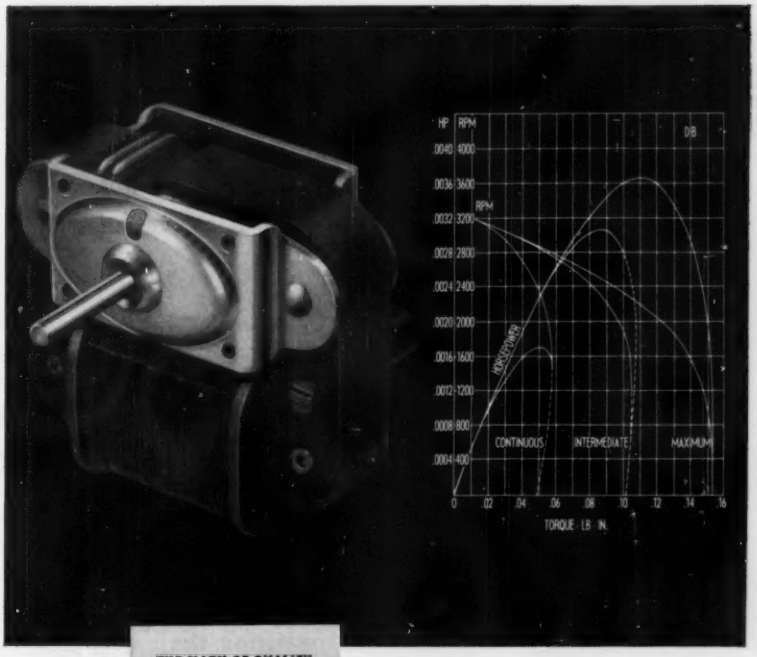
Circle 748 on Page 19

Relief Valves

Catalog of handwheel valves for oil bypass relief applications contains photographs and tables for the various series. Catalog also shows frequently specified modifications such as stainless trim, panel-mounting design, use of wrench or wing-type locking nuts, and others. Basic specifications are included, as well as ordering information. 4 pages. Fulflo Specialties Co. Inc., 437 Fancy St., Blanchester, Ohio.

Circle 749 on Page 19

Barber-Colman Type B precision-made, low-cost small motors (up to 1/150 hp) for appliances, vending machines, projectors, fans, office machines



THE MARK OF QUALITY

BARBER COLMAN

LOW NOISE LEVEL

LONG-LIFE ALIGNABLE BEARINGS

LARGE OIL RESERVOIRS... AUXILIARY OIL CUPS AVAILABLE TO QUADRUPLE CAPACITY

VARIETY OF MOUNTING ARRANGEMENTS

STACK THICKNESSES: 9/16" and 15/16"

SHAFT DIAMETERS: 1/8" and 5/32"

a-c small motors

Ideal for driving fans, blowers, and gear trains, this high-quality motor is built to give long, trouble-free service. You'll find it an outstanding general-purpose motor featuring small physical size combined with high starting torque. And the price is right . . . to bring extra economies to your product . . . as well as an extra measure of dependability. Next time you need a motor in this size and power range, look at this one carefully . . . it will pay you well.

WRITE FOR NEW QUICK REFERENCE FILE on the complete line of Barber-Colman a-c small motors: unidirectional, reversible, synchronous. Up to 1/20 hp. With or without reduction gearing . . . open or enclosed types. Stator and rotor sets also available. Free engineering service.

BARBER-COLMAN COMPANY

Dept. K, 1273 Rock Street, Rockford, Illinois

Circle 531 on Page 19

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.

From the office of
ARTHUR N. DANIELS,
President

RE: Instrument Ball Bearings

Gentlemen:

Most of us didn't learn much about anti-friction bearings in Engineering School. In my own case, we learned the difference between ball, roller and needle bearings, and that's about all. Literature on the subject is sparse; the variety of types, sizes and extra features is vast. All have their limitations, advantages and disadvantages.

This is a plea, then, for taking a Bearing Engineer into consultation before your layouts or designs are frozen. He is a professional and his services are free. We have ten of them, at your disposal, in addition to a staff of specialists at our home office.

True, they have an axe to grind: to sell you instrument ball bearings. But none of them wants to make recommendations that will fail to meet requirements, or to propose a marginal solution. Ethics of course prohibit their revealing your plans to others. Sometimes they will say "No," or "Maybe," or "Tests must be run." We've not accumulated all the answers yet, doubtless never will. Then, for confirmation, a competitor can be called in. We have a few who know a little about it. And, as sometimes happens among professionals, he may dissent, leaving the judgment up to you.

We believe too that our own new 150-page Design Manual is the most comprehensive treatise on instrument ball bearings published. We shall be glad to send you a registered copy by return mail.

Sincerely,

A. N. Daniels
President

Circle 532 on Page 19

Magnetic Reed Switches

Informative booklet contains descriptive material and specifications on two models of magnetic reed switches, plus information about the switches in general. Charts and diagrams on actuation methods and mechanism, both mechanical and electromagnetic, are provided. Test charts for life expectancy, method of code identification, and permanent-magnet chart with typical make and break contact distances are shown for the proper selection and application of the switches. 6 pages. Hamlin Inc., Lake & Grove Streets, Lake Mills, Wis.

Circle 750 on Page 19

Accelerometers

Bulletin B-4 illustrates and describes nine series of linear and angular accelerometers available in excitation frequencies from 400 to 10,000 cps and acceleration ranges from ±0.1 to ±700 g. Each unit is pictured, features are pointed out, and list of applications is given. 4 pages. Schaevitz Engineering, P. O. Box 505, Camden 1, N. J.

Circle 751 on Page 19

Plastic Lenses

Low-cost, lightweight, optically ground and polished, solid-plastic lenses are described in new two-color Bulletin 100. Advantages, applications, specifications, and manufacturing facilities are discussed. Various types of lenses are pictured and described. 4 pages. Applied Products Div., Fostoria Corp., Dept. 90, Buck & County Line Roads, Huntingdon Valley, Pa.

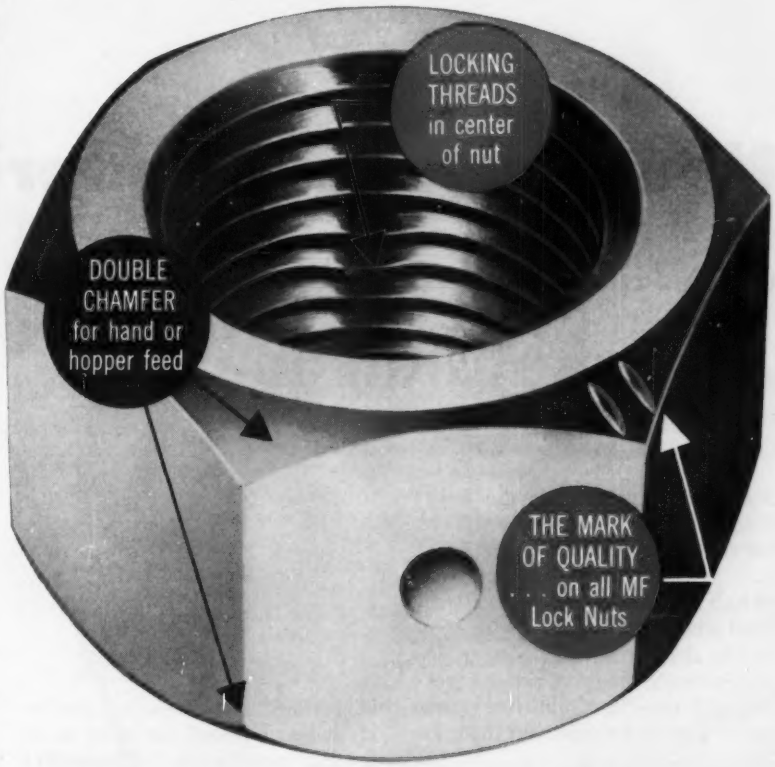
Circle 752 on Page 19

Turbine Flowmeter

Illustrated technical information bulletin D-225 describes Micro-Meter Series 4000 flowmeter. Sizing chart indicates meter sizes required for various flow ranges from 0.004 to 0.6 gpm. Flowmeter is shown in a configuration drawing with dimensions. Graphic illustration is given of the available electronic instrumentation to utilize unit's signal for batch control, analog flow-rate indication, or digital flow-rate indication. 4 pages. Write on company letterhead to Potter Aeronautical Corp., Route 22, Union, N. J.

Semiconductor Devices

Short-Form Catalog covers over 800 semiconductor devices. It includes ratings, characteristics, and descriptive data for silicon-glass diodes; silicon small, medium, and high-power rectifier cells; high-voltage cartridge rectifiers; zener diodes and reference elements; silicon-controlled rectifiers; silicon and selenium rectifier stacks; silicon solar cells; selenium contact protectors. Also included is a listing of JEDEC rectifier types, with cross reference to device classification, rating, and page number. 24 pages. Write on company letterhead to International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.



Build better products...faster...with

MF TWO-WAY LOCK NUTS!

The MacLean-Fogg Two-Way Lock Nut has the features designers and production men want. Check them off: (1) It is double chamfered—goes on from either side—is ideal for either hand or hopper feeds. (2) The lock is in the *center of the nut*—permits fastest starts—allows bolt end to be below or flush with top of nut. (3) Two-Ways are economical; reusable; better looking on your finished product.

Circle number on reply card for catalog and technical data.

MAC LEAN-FOGG MF LOCK NUTS

MacLean-Fogg Lock Nut Company
5535 N. WOLCOTT AVENUE
CHICAGO 40, ILLINOIS

1925 35 1960 ANNIVERSARY

Circle 533 on Page 19

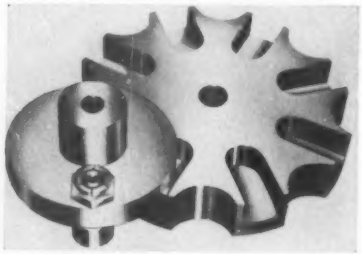
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Geneva Drives

have variety of hub and bore diameters

Standard Geneva drives are available with 3 to 24 indexing stations for shaft center distances from 3 to 6 in. in ¼-in. increments. A variety of hub and bore diameters is offered. Steel wheels are furnished with Meehanite driving wheels. Drives insure accurate indexing, positive locking, and smooth, trouble-free operation. Center distances less than, intermediate, or greater than the standard 3-6 in. are available upon request. **Genevamatic Engineering Corp.**, P. O. Box 10386, Tampa 9, Fla.

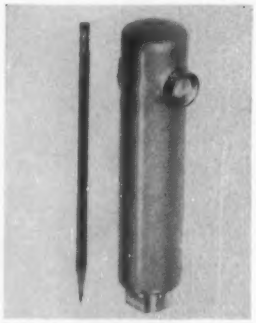


Circle 753 on Page 19

Photoelectric Control

contains transistorized printed circuit

Tubular photoelectric control 22LB5 incorporates a transistorized printed circuit contained in a flashlight-type cylinder 7½ in. long by 1⅝ in. diam. Conduit hub is threaded for ½-in. pipe for simple, direct mounting in any position. Unit contains a sensitive cadmium-selenide cell, printed-circuit transistorized amplifier, power transformer, and output relay requiring little or no maintenance. With matching light source, relay operation with light impulses as short as 0.015 sec is possible at light beam ranges up to 20 ft. Single-pole, double-throw relay contacts permit flexibility in industrial application. **Photoswitch Div., Electronics Corp. of America,** One Memorial Drive, Cambridge, Mass.

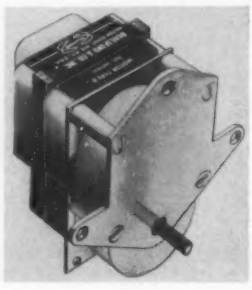


Circle 754 on Page 19

Instrument Motor

has output speed from 2 to 200 rpm

Capable of sustained output torques of 40 oz-in. at 2 rpm, high-torque motor fulfills the need for an instrument quality dc motor capable of relatively high output torques at low power input levels. Motor contains neither revolving windings nor sliding mechanical commutators. Permanent-magnet rotor is supported on Grade-5 instrument ball bearings. Standard output speeds from 2 to 200 rpm are available. Unit is also available without reduction gear at a nominal speed of 3000 rpm. Motor is wound for input voltages of 3, 6, 12, and 24 v dc. **Brailsford & Co. Inc.**, 670 Milton Rd., Rye, N. Y.



Circle 755 on Page 19

Decorative Material

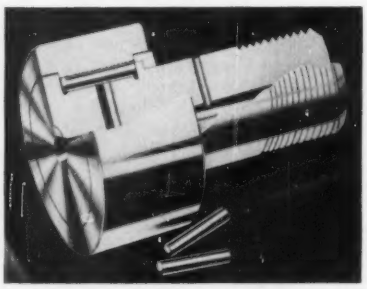
is furnished in three new patterns

Three new patterns of Metalflake precision-cut metallic chips for decorative use are now available, bringing to nine the number of patterns. New patterns are offered in diamonds, comets, and microflakes shapes. Chips are adaptable to a wide variety of applications ranging from floor and wall covering to upholstery, apparel, and paper products. They can also be incorporated into paints. **Dobeckmun Co.**, P. O. Box 6417, Cleveland 1, Ohio.

Circle 756 on Page 19

Cam Follower Bearings

are available for heavy-duty use

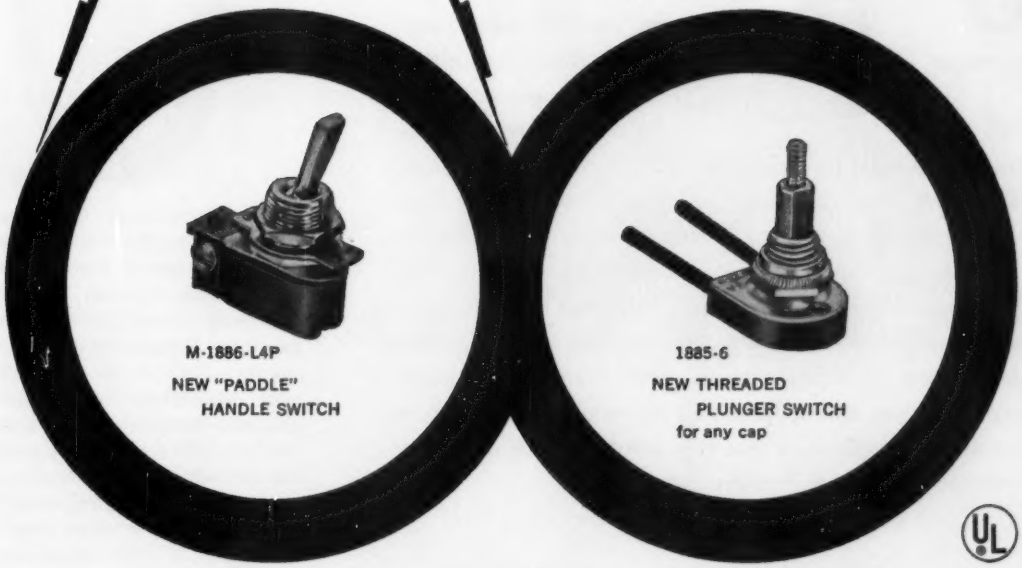


Two new series of heavy-stud cam follower roller bearings have increased diameter studs that provide greater shear strength to accommodate excessive stud deflection in critically loaded track, guide, support, and cam follower applications. Included are regular CFH and SCFH models with integral seals. Both are interchangeable with standard cam followers except for larger stud diameters. Roller diam-

precision engineered
control switches

designed with brand new features

Keeping pace with design engineers, Circle F offers modern control switches for every possible application. New economies are now possible through the use of standard switches readily modified to meet any particular specification. Circle F's advanced standards of quality-controlled manufacture makes possible assembly-line production of highest quality "custom-made" switches in less time and at lowest costs. Whatever your need, write Department S for fullest information and helpful engineering assistance.



M-1886-L4P
NEW "PADDLE" HANDLE SWITCH

1885-6
NEW THREADED PLUNGER SWITCH
for any cap

L-40 L-52 1885 1903

CIRCLE F's "Fine" Silver Contacts reduce arcing on slow-make, slow-break AC and insure long, dependable switch life.

CIRCLE F MFG. CO.

TRENTON 4, NEW JERSEY • For your wire requirements: Eastern Insulated Wire Corp., Box 591, Trenton, N. J.

Machine *down-time* is measured in seconds when you're repositioning, adding, or removing

APEX

QUICK-CHANGE UNIVERSAL JOINT ASSEMBLIES

Standard NEW equipment for most multiple spindle tools.

Standard REPLACEMENT equipment for any multiple spindle tool

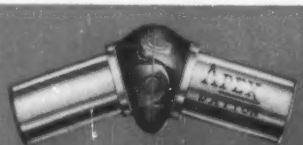
Spring tension holds the Apex universal joint assembly firmly in driving position, yet lets you move or replace the unit by simply compressing one end and lifting it clear of the drive or spindle shaft. You don't waste time removing pins, rivets or other types of fasteners because there aren't any on an Apex assembly.

If you have Apex quick-change universal joint assemblies on your multiple spindle machines, you know how much time and money they save. If you don't have them, you can start saving now by replacing with Apex. Hub ends to match present drives and spindles can be furnished; if you have an unusual application that may involve special designs or materials, we'll give it prompt attention.

SEE OUR CATALOG IN SWEET'S

or write, on your company letterhead please, for Catalog 28 and Data Sheet. For special applications, send sketch or print for prompt recommendations and quotation.

THE APEX MACHINE & TOOL CO.
1042 South Patterson Blvd.
DAYTON 2, OHIO



Phantom view of Apex universal joint with lubricant-retaining cover, an exclusive Apex development. Apex covered joints operate efficiently in wet, dry, corrosive or abrasive atmospheres and in extremes of temperatures.

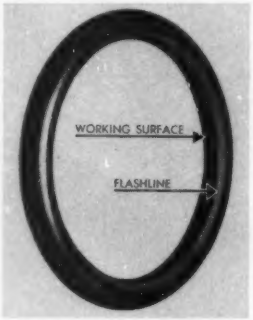
eter for both models start at 0.5 in., and stud diameters from 0.25 in. Capacity range is from 470 to 20,750 lb at 100 rpm. All component parts are of heavy-duty construction. They feature full-race-width rollers and a hardened end plate to resist wear under misalignment. **Bearing Div., McGill Mfg. Co. Inc.,** Valparaiso, Ind.

Circle 757 on Page 19

O-Ring Seals

for use over a wide range of pressures

Two types of new O-rings are now available: Moving type for reciprocating seals, oscillating seals, rotary seals, pneumatic seals, and small drive belts; and nonmoving type, as



vacuum seals, seat seals, and flat gaskets. Flashline on the seals is not placed on the centerline where ring is subject to wear. Seals operate efficiently over a wide range of pressures, temperatures, and tolerances. Limitations are conditions such as extremely high temperatures, excessive pressures, rotary speeds exceeding 1500 fpm contact speed, and contact with fluids normally injurious to any rubber compound. Rings are furnished in sizes from 1/32 to 6½ in. ID. **Shurclose Seal Co.,** 17411 E. Warren, Detroit, Mich.

Circle 758 on Page 19

Turns-Counting Dial

needs no auxiliary mounting hardware

Model 30 turns-counting dial measures 1 13/16 in. diam by 1 in. deep, and is designed for ¼-in. shaft mounting. It has a satin-chrome-finished housing with a black, insulated, knurled grip. Shaft posi-

Circle 535 on Page 19

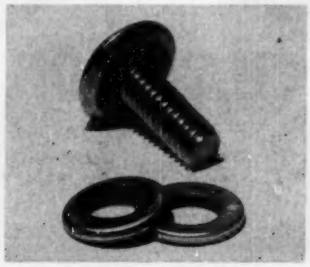
tion is indicated in 1/100-turn increments. As each full turn is completed, transfer of single number appearing in viewing window occurs while knob is rotating less than one scale division. Bevelled window allows reading at extreme angles. Simplified construction eliminates need for auxiliary mounting hardware. Brake mechanism allows dial to be set and locked with one hand without disturbing the setting. When locked, braking catch always appears at the same place on all diams and cannot be shaken loose by extreme vibration or shock. **Spectrol Electronics Corp.**, 1704 S. Del Mar Ave., San Gabriel, Calif.

Circle 759 on Page 19

Sealing and Cushioning Washer

incorporates compressible, flowable-type insert

Barclad single-unit washer has a compressible, flowable-type insert enclosed in a metallic encasement to fit any round, hex, or flat-headed fastener. Tightening of fastener forces sealing or cushioning material in the metallic encasement downward onto the fastened member and into clearance hole between fastener and fastened member, effecting a perfect seal or cushion. Washer is available for light, medium, and high-torque requirements. It can be supplied in any metal or finish as required, with a variety of inserts that solve all sealing or cushioning problems. As a sealing washer,



for 1 bomber:

...Up to 50 Different Brush Types

...Over 300 Brushes Needed

...and Stackpole makes all types!

STACKPOLE

***HIGH-ALTITUDE AVIATION* BRUSHES**

STACKPOLE CARBON CO., ST. MARYS, PA.

BRUSHES, FOR ALL ROTATING ELECTRICAL EQUIPMENT • ROCKET NOZZLES • ELECTRICAL CONTACTS • CERAMIC MAGNETS • FERRITE CORES • GRAPHITE BEARINGS & SEAL RINGS • PUMP VANES ELECTROCHEMICAL ANODES • WELDING & BRAZING TIPS • VOLTAGE REGULATOR DISCS • FIXED & VARIABLE COMPOSITION RESISTORS • RELATED CARBON, GRAPHITE AND ELECTRONIC PRODUCTS.

Circle 536 on Page 19

Heart of the Control System

'DIAMOND H' Relays

"Diamond H" relays have a record of high reliability proved in critical applications ranging from missiles to nuclear submarines. That's why increasing numbers of engineers are specifying "Diamond H" relays in the heart of their control systems.

Hart makes these basic types of relays:

- **Miniature, hermetically-sealed aircraft-missile relays, (Series R and Series S).**
- **High-speed sensitive polarized relays (Series P).**
- **General purpose AC/DC relays (Series W)**

Technical literature outlining the wide range of characteristics available in each type relay is yours for the asking. You'll find "Diamond H" engineers skilled in optimizing the basic designs to meet your specific requirements.

Tell us your needs . . . by phone, wire or letter.

THE **HART**

MANUFACTURING COMPANY

118 Bartholomew Ave., Hartford 1, Conn.

Phone JAckson 5-3491

Circle 537 on Page 19

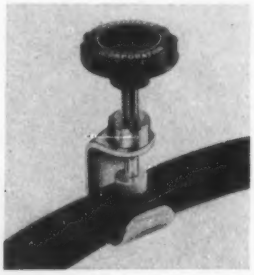
unit seals air, liquids, or gases at low and high pressure, in a temperature range of −100 to +1200 F. As a cushioning washer, it prevents cracking or chipping of porcelain or enameled surfaces. Washers can be supplied in all sizes in permanent and re-usable types. **L. J. Barwood Mfg. Co. Inc.**, Everett 49, Mass.

Circle 760 on Page 19

Pinch Valve

controls flow through constriction of hose wall

Pinch valve enables controlling flow of inks, paints, adhesives, slurries, and other fluids pumped to flexible tubing or hose lines. Valve slips over the OD of the



hose and controls flow through gentle constriction of the tubing wall. Control is immediate and positive, and eliminates the need for extensive fittings. It also eliminates build-up of solids within the line. Valve effects complete shut off in the line without placing harmful stress on tubing or hose. Sizes range from ¼ to 1½ in. ID. **Graymills Corp.**, 3705 N. Lincoln Ave., Chicago 13, Ill.

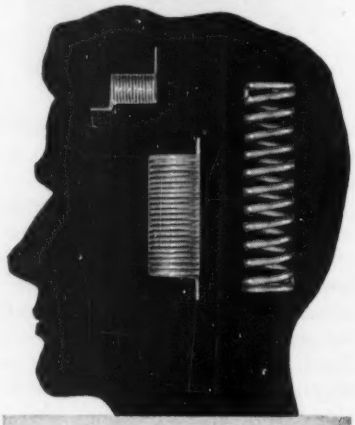
Circle 761 on Page 19

Nickel-Cadmium Battery

rechargeable unit has 4 amp-hr capacity

Rechargeable, hermetically sealed cell of 4 amp-hr capacity has unusual energy in its size and weight. The 1.25-v, standard D-size cell can be discharged at loads up to 50 amp and supplies hundreds of cycles of charge and discharge. Cell is particularly adaptable for large current requirements and uses where space and weight are a premium such as portable, cordless appliances, photoflash equipment, satellite and missile

SPRINGS ON YOUR MIND?



• Your next thought should be of the Spring Engineers at John Chatillon & Sons. Send them your blueprints and specifications for study and recommendation.

• With more than 120 years of experience and knowledge at their command, they can provide you with the exact spring you require—on time, at competitive prices.

• Chatillon has the trust of the largest users of springs in the world because of the Chatillon reputation for filling orders that others would consider impossible.

• Next time, benefit by the thorough knowledge of Chatillon Spring Engineers. They'll be glad to help you. Send your blueprints to: Department D-2.

JOHN CHATILLON & SONS

SPRING DIVISION

48 FRANKLIN ST., N. Y. 13, N. Y.

Manufacturers of Precision Springs and Force Measuring Instruments Since 1835

Circle 538 on Page 19

applications, or as standby power. Cell can be trickle-charged to maintain full charge indefinitely, and when connected in series form batteries of standard voltages. Unit can be charged and discharged in any position. **Nicad Div., Gould-National Batteries Inc.**, Roblyn Avenue, St. Paul 1, Minn.

Circle 762 on Page 19

Aluminum-Coated Steel Wire

has high electrical conductivity

Aluminum-coated wire, Alstan, has applications in fields where strength, electrical conductivity, and corrosion resistance, or a combination of these properties, are required, such as in power transmission. Wire has an aluminum coating of 20 to 60 per cent of total cross-sectional area, giving electrical conductivity of 20 to 40 per cent of equivalent sizes of copper wire. Limited quantities are now available in a range of wire sizes. Process permits a broad range of wire diameters, strengths, and coating thicknesses. **National-Standard Co.**, Niles, Mich.

Circle 763 on Page 19

Fluid Coupling

incorporates positive, push-pull lock

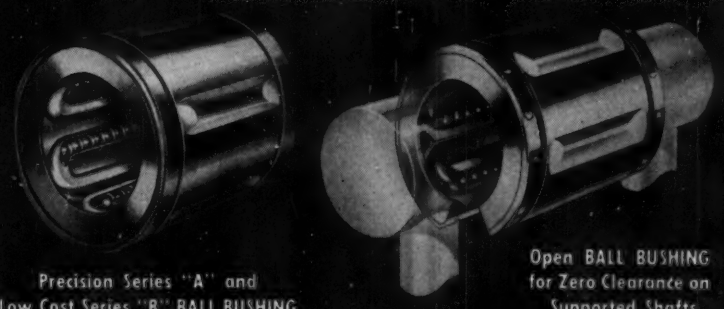
Quick-disconnect fluid coupling with self-sealing features assures

NOW! *Adjustable Diameter and Open* THOMSON

BALL BUSHINGS

Adjustable Diameter BALL BUSHING for Zero Clearance

The BALL Bearing for *all* your **LINEAR MOTIONS**



Precision Series "A" and Low Cost Series "B" BALL BUSHING

Open BALL BUSHING for Zero Clearance on Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

LOW FRICTION · ZERO SHAKE OR PLAY
ELIMINATE BINDING AND CHATTER
SOLVE SLIDING LUBRICATION PROBLEMS
LONG LIFE · LASTING ALIGNMENT

The various types cover a shaft diameter range of 1/8" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.

THOMSON INDUSTRIES, Inc.
Dept. E, MANHASSET, NEW YORK

Circle 539 on Page 19

Also Manufacturers of NYLINED Bearings . . . Sleeve Bearings of DuPont Nylon, and 60 CASE . . . Hardened and Ground Steel Shafting

NEW NEW NEW NEW NEW NEW

NOW! 1½ TONS PER SQUARE INCH CONTINUOUS RATING

*Tested at 2½ tons per square inch

Pathon
3000 PSI
HYDRAULIC CYLINDERS

The New Pathon Series 3H Hydraulic Cylinders are not an adaptation or modification of existing models, but specially designed 3000 P.S.I. Cylinders, continuous service. The 3H Series is available in a wide range of bore sizes and standard mounting types. Like all other Pathon Cylinders, the 3H Series features:

- Single screw thread head attaching method
- Increased strength and fatigue life
- Low Stress Concentration
- Compactness

Illustrated, Model 3H 33 incorporating spherical bearing at the pin connection.

FOR ADDITIONAL INFORMATION
WRITE—WIRE—PHONE TODAY

Pathon MANUFACTURING COMPANY
3823 PACIFIC AVE., CINCINNATI 12, OHIO

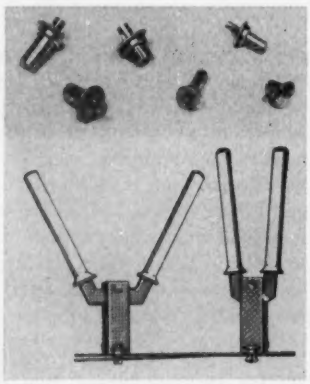
FLUID OPERATED AND CONTROL EQUIPMENT

zero leakage and no air inclusion or other contamination during connect-disconnect. Symflow disconnect features a positive, push-pull lock that can be operated with one hand or with remote control mechanical or electromechanical devices. Locking arrangement eliminates threaded joints, and permits minimum size without loss of strength. After disconnect, no seals are exposed, and coupling valve maintains full pressure of 4000 psi. Temperature ratings, dependent upon type of seal, range from −65 to +400 F. Couplings have stainless, one-piece housings, and are available for ¼ through 1¼-in. tube sizes. **Symetrics Inc.**, 3100 Airport Ave., Santa Monica, Calif.

Circle 764 on Page 19

Blind Fastener

for riveting thin, unsupported sheets



Squeez Riveting offers a means of securing thin, unsupported sheets with rivets by using an inexpensive, pocket-size, plier-type tool. Materials can be riveted tightly from one side of the job with only hand pressure. Rivets also make possible a low-cost method of fastening clips, clamps, and brackets to a variety of materials, including wood, ductwork, and neon signs. Shape of the Squeez Rivet head provides a recessed collar which makes suitable anchor for strap hangers, wire clips, and springs. Rivet itself is furnished in two diameter sizes, ⅛ and 3/16 in., with a nominal grip from 0.016 to 0.266 in. Three-grooved pin drives the rivet, which applies expansion to force the sheets together. Equal pressure is exerted

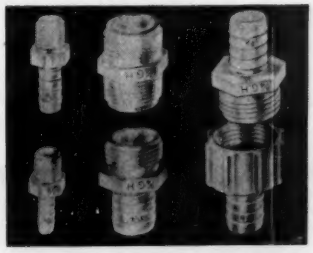
Circle 540 on Page 19

against work side and blind side of material to push sheets together and prevent deformation. **Southco Div., South Chester Corp.**, 200 Industrial Highway, Lester, Pa.

Circle 765 on Page 19

Hose Fittings

of high-impact, nontoxic nylon



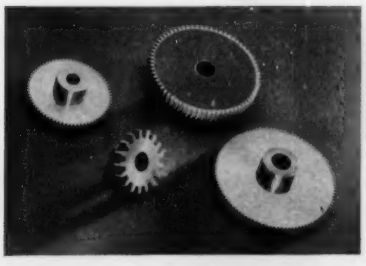
Hose couplings, nipples, and adapters are available in high-impact nylon in sizes ¼ to 1 in. Standard iron pipe or garden-hose threading, or combinations of both, is furnished. Tuff-lite fittings provide high resistance to abrasion, corrosion, contamination, and heat, and are breakproof and crushproof. Units are desirable for hose and tubing conducting potable fluids. **Dixon Valve & Coupling Co.**, Dept. NW, 1700 N. 2nd St., Philadelphia 22, Pa.

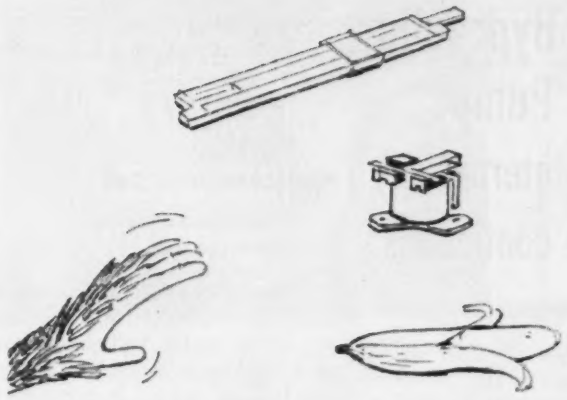
Circle 766 on Page 19

Precision Gears

in 24 to 200 diametral-pitch range

Stock precision gears meeting military requirements cover a diametral pitch range including 24, 32, 48, 72, 80, 96, 120, and 200. They are available in stainless steel, aluminum, nylon, and linen phenolic, in either split or clamp-type hubs. Fabrication meets AGMA standards. Gears are available in Precision 1, 2, 3 and ultraprecision 1





Will he make the right choice and find True Happiness?

With enough expertly "programmed" and ingeniously dispensed training by a machine, even monkeys can be taught all sorts of marvelous things. (There are those who say that for the rewards illustrated, even a monkey would know enough not to pick the Sigma relay. At times we too wonder if some of our customers wouldn't have been better off if they'd chosen a banana instead of one of our relays.) At any rate, we salute the hard-working souls who try to get other people to think; if their "teaching machines" lack human fervor and originality, as some say, perhaps the critics are confusing the methods with the accomplishments.

Continuing our discussion of Sigma relays vs. bananas (we've decided that *they're* our real competitive threat, not transistors), it is the Application that decides all. We can't hold a candle to their enclosure, and while heat improves them up to a point it's apt to make relays dry up and get lethargic instead of just squishy. What hurts the most, though, is that if a banana doesn't work in the application you had in mind, you can always eat it; in 20 years, we've never been able to offer customers that consolation.

There's a ray of hope for relays, however, from one quarter where slide projectors, electric shocks, peanut butter and other assorted elements are being used in teaching machines. In one device relays and photocells "read" the student's answer to a slide-projected question, via selected light beams passing through holes in the edge of the slide. This particular programmer uses twelve Sigma Series 11 relays, noted for their compatibility with both monkeys and people. The machine can handle up to 4096 different questions (12 relays x 2 positions = 2^{12}), and its output from the relays' contacts can run a congratulatory or reprimanding indicator, reward dispenser or some other electrically-actuated device. To the "student" using the machine, the fruits of his labors may be either literal or figurative, depending on what's connected to the machine. This, in turn, is usually determined by whether the student is a smart monkey or just a human being. Another good feature is that the inventor* is Sigma's Sales Manager's cousin's husband, which assures us a certain degree of customer sympathy and prompt payment of account.

This educationally-oriented advertisement is one in a series of public-spirited messages from Sigma, wholeheartedly devoted to fostering greater awareness among relay users. For those not yet ready to buy, Sigma once again offers a small remembrance gift. If you've got 26¢, send it to Sigma's Advertising Manager today, for your Big Application Boon of Oblige Noblesse (address "BABOON Branch"). Quantities limited by our patience; act now.

*Davis Scientific Instruments, 12137 Cantura St., Studio City, California

SIGMA INSTRUMENTS, INC.

89 Pearl Street, So. Braintree 85, Mass.

An Affiliate of The Fisher-Pierce Co. (since 1939)

Circle 541 on Page 19

Portable Hydraulic Power Pumps

10,000 psi intermittent
6,000 psi continuous

No. 797-E-SA

No. 797 series
213 cu in. per min. at 10,000 psi

Extra-high-speed drive at high pressure. Applies to a wide range of hydraulic systems. Compact unit . . . pump reservoir, and control valve in one housing. Simply operated, 2-position control handle with advance and return positions. Available with 4-way valve for double-acting rams. Delivers 213 cu in. of oil per min at 10,000 psi with 3 hp a-c motor . . . 106 cu in. with 2 hp motor.

No. 797-G-SA is same pump powered with 4½ hp 4-cycle, air-cooled gasoline engine.

No. 798 series
28 cu in. per min. . . . at 10,000 psi

Easily carried, high-pressure pump. Has exclusive fast approach . . . high volume, low pressure . . . automatic change-over to low-volume, high-pressure drive. Develops 6,000 psi continuous pressure, 10,000 psi intermittent. Choice of integral 2-way or 4-way valve. Built-in 115 - 230 V ¾ hp a-c motor. Also available with built-in 1.7 hp gasoline engine, universal or low-voltage motor. Write for illustrated data sheets.

ALSO A SELECTION OF HYDRAULIC HAND PUMPS AND VALVES

GREENLEE TOOL CO.
1775 Columbia Avenue
Rockford, Illinois

GREENLEE

Circle 542 on Page 19

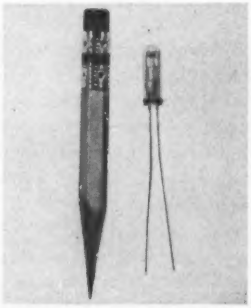
classes. Instrument Div., Sterling Precision Corp., 17 Matinecock Ave., Port Washington, L. I., N. Y.

Circle 767 on Page 19

Photoconductive Cell

of cadmium sulfide is miniature unit

ORP 60 microminiature cadmium-sulfide photoconductive cell mounted in a sealed, all-glass transistor envelope measures 0.59 in. long and 0.25 in. diam. It is top-sentitive and has a 70-mw dissipation rating. Unit is suited for use in computers where it functions as a



noiseless resistor. It is also used to advantage in light-operated flip-flop circuits. Other applications include use in television receivers, automatic headlight dimmers, light-sensitive relays, illumination stabilizers, color density and brightness control, perforated tape readers, alarm and safety devices, and automatic counting, filling, and loading controls. Side-sensitive version, ORP 61, is also available. Units have a sensitivity 10,000 times greater than conventional phototubes, as well as high dissipation ratings. Semiconductor & Special Purpose Tube Div., Amperex Electronic Corp., 230 Duffy Ave., Hicksville, L. I., N. Y.

Circle 768 on Page 19

Dual-Outlet Blower

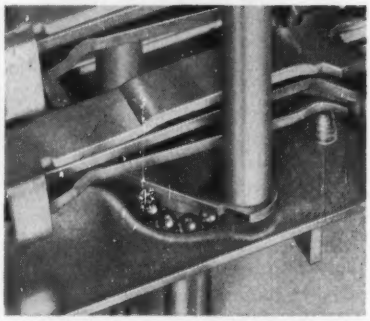
has one-piece phenolic plastic housing

Lightweight Model 8481 dual-outlet blower for heat dispersion has a one-piece, impact-resistant, phenolic plastic housing with aluminum motor-plate. Unit is 6⅜ in. from top to bottom, and total width of motor and blowers assembly is 7¾ in. Motor is rated 115 v, 60 cycles. Unit

ABBOTT

PRECISION-QUALITY BEARING BALLS

are indispensable to the proper function of sensitive, reliable auto radio tuners



To uphold its redoubtable reputation as a communications specialist, a leading manufacturer of automotive radio systems must be certain that every component used in its assemblies performs reliably.

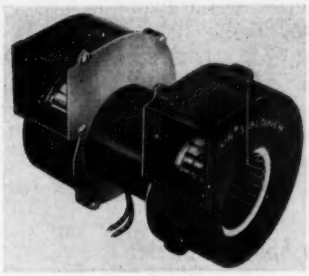
For example, when this auto tuner assembly is coupled to the electrical system, it must provide positive location and low torque to ensure fine tuning . . . and dependable, precision-quality bearing balls perform a vital function. The bearing balls provide uniform torque between the conical shaft and the bearing race, without introducing tortional strain and undesirable angular displacement . . . and customer requirements for life expectancy and non-degradation in function of the complete assembly are repeatedly satisfied.

Abbott precision-quality bearing balls adapt easily, perform reliably, and last! A wide range of sizes is available. Write for complete information.

Write for copy of Bulletin AP-1

THE ABBOTT BALL COMPANY
118 RAILROAD AVE.
HARTFORD 10, CONN.

Circle 543 on Page 19



incorporates sealed ball bearings which require no maintenance. It operates in an ambient temperature range of −34 to +93 C. Total free-air delivery is 150 cfm; unit is also rated at 90 cfm at 0.4 static pressure. **Ripley Co. Inc.**, Middletown, Conn.

Circle 769 on Page 19

Casting Resins

for potting or encapsulating use

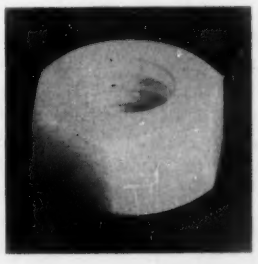
Two casting resins are available for industrial use. Melpak E-200, a two-component system, satisfies requirements for most general-purpose potting, encapsulating, and casting applications. It has excellent adhesion to most plastics, resins, and ceramics. Resin cures at room temperature, and is self-extinguishing. Melpak P-200 is a three-component unfilled polyester resin suited for small castings, for potting electronic components, or for encapsulating miniature assemblies. It cures rapidly at room temperature without external heat, and pours easily, filling cracks, voids, and contours. **Special Products Dept., Melpar Inc.**, Arlington Blvd., Falls Church, Va.

Circle 770 on Page 19

Screw Nut

is double chamfered and countersunk

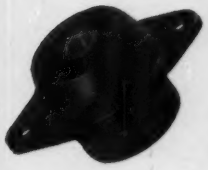
Low-priced 101 nylon hex machine-



NEEDED:
ISOLATION FROM
HIGH ENGINE TORQUE
AND SHOCK

... to isolate frame and operator from the high engine torque, shock and violent bursts of intermittent power delivered by the engine on a 6-ton crawler-tractor; also to protect engine from shock of heavy pounding.

ANSWER:
STANDARD
MB ISOMODE (trm)
TYPE 5 MOUNTS



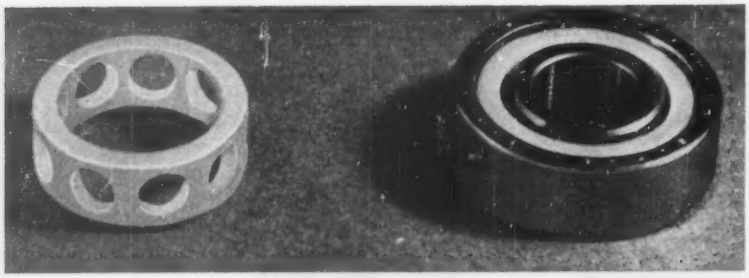
The Isomode Type 5 Mount isolates equally the six possible modes of vibratory motion. With core in balanced compression and shear, it offers high load capacity and endurance in compact size. It is safely self-snubbing to control damaging overloads. And it can take an extraordinary amount of punishment.

WHAT'S YOUR
MOUNT PROBLEM?

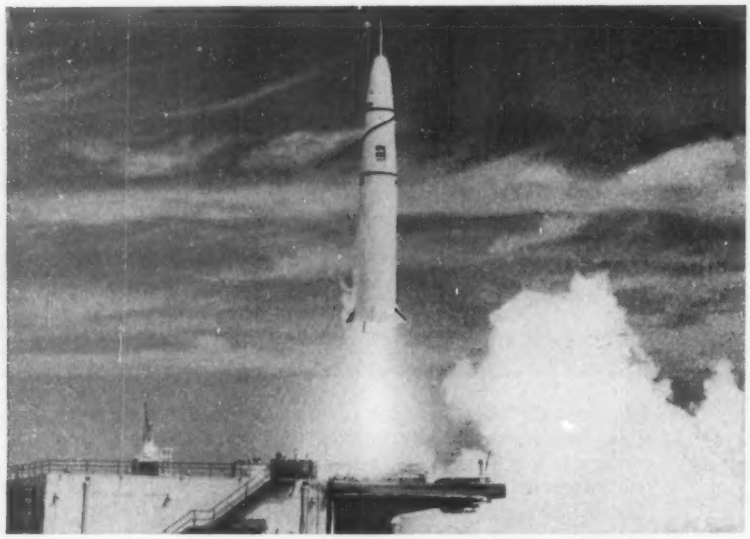
MB has specialized in vibration isolation for over 20 years. It may very well be that an existing standard MB mount or modification thereof is the answer to your vibration control problem. If not, MB has the experience and personnel to find the right answer for you. Write us for complete information—ask for Bulletin 418-1.

MB ELECTRONICS
A DIVISION OF TEXTRON ELECTRONICS, INC.
1056 State Street, New Haven 11, Conn.

Circle 544 on Page 19



Oil-filled **NYLASINT®** retainer helps keep missiles on target



Ball bearing retainers of oil-filled, micro-porous Nylasint have unique resistance to bleeding under extremes of temperature, pressure and acceleration. Leading builders of inertial guidance systems are taking advantage of Nylasint's unique oil-holding characteristics for improved lubrication and performance of gyro rotor bearings. Nylasint retainers prevent navigational errors induced by even the slightest shifting of oil masses.

Sintered from finely divided nylon powder and impregnated with oil, Nylasint parts retain up to 50% (by weight) of the lubricant to minimize friction in bearing and wear applications. Almost 20% of the initial oil is retained at accelerations of 15,000 G's.

Inorganic additives also give resilient Nylasint parts outstanding dimensional stability, high load capacity, and increased wear resistance.

For complete technical data on Nylasint, and its design possibilities, write for new Nylasint Bulletin.

POLYPENCO industrial plastics

Halex Corporation
a subsidiary of
The Polymer Corporation
Reading, Pa.

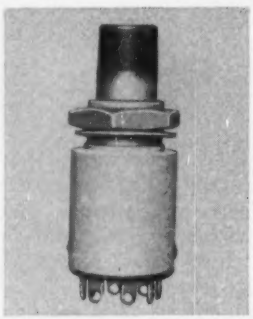
screw nut is available in sizes 2-56, 4-40, 6-32, 10-32, 10-24, 1/4-20, and 1/4-28. Nut is double chamfered and double countersunk for automatic feeding. **Nylogrip Products**, 570 Pleasant St., Watertown 72, Mass.

Circle 771 on Page 19

Pushbutton Switch

meets MIL-S-6743

Series WC1500 pushbutton switch features moistureproof construction, small cylindrical case design, and a life of 25,000 operations minimum at rated load. Available as either a



double-pole, double-throw or four-circuit type, it meets MIL-S-6743. Available with or without indicator light, unit is rated at 2 amp inductive or 4 amp resistive, 28 v dc; it fits 5/8-in. hole. Six plunger-cap colors are obtainable. **Control Switch Div., Controls Co. of America**, Folcroft, Pa.

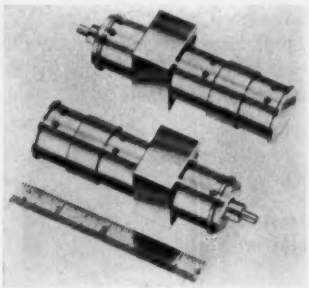
Circle 772 on Page 19

Clutch-Brake Unit

of all-stainless steel

Model 201-100-1 unit is a differentially coupled pair of clutches with an integral, antibacklash brake. Input shaft, output shaft, and 1.062-in. diam mounting pilot are all at one end. The 0.375-in. diam input shaft can be driven in one direction continuously while 0.187-in. diam output shaft remains stationary or is driven in either direction, depending on which of three sets of terminals are electrically energized. In the event of a power failure, brake unit locks output shaft to housing with zero backlash grip. Unit features all-stainless-steel design for

Circle 545 on Page 19



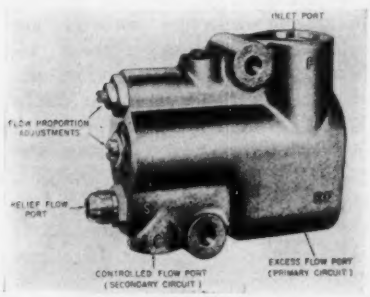
maximum humidity and salt-spray resistance, and molybdenum-disulphide-impregnated sleeve bearings throughout. Coil terminations are made inside the unit to eliminate accidental damage when making electrical connections. Weight of unit shown is 16 oz. It is normally wound for 24-28 v dc. **Marketing Computers Inc.**, 50 St. Benedict, Florissant, Mo.

Circle 773 on Page 19

Flow-Divider Valve

provides double-duty flow control

New Flow-divider valve directs output from one pump to either of two or more hydraulic circuits, or to all circuits, simultaneously, eliminating extra pumps. Adjustment feature diverts desired portion of pump output to secondary circuit when primary circuit is inactive, then automatically reduces or stops secondary flow when primary circuit is pressurized. Two manual adjustments divert primary and secondary flow rates in any proportions required. Built-in relief valve protects pump from over-pressure at controlled flow port. Valve operates quietly on low-circulation pump pressure, handling all standard hydraulic fluids at temperatures to 250 F. Nine models are available with or without manual-controlled flow adjustment,



with "engineered" drawing and tracing media

Architects, draftsmen, engineers can spend more hours creatively . . . less hours drawing guide lines, lettering, and performing similar routine tasks — by using Ogilvie Services and Media.

The result of combined designing, production and printing standards of optimum excellence, Ogilvie is specified throughout Industry wherever quality and exacting tolerances are demanded.

Drawing forms; time-saving "Drop-Out" grids; precision grids for printed circuitry (and similar technical applications); and all Mylar, Cronaflex, Tracing Cloth, Tracing and Drawing Paper requirements . . . are just a few of the many Ogilvie "engineered" media available.

For any standard or special need . . . and for the most modern production and printing methods (Press equipment up to 48½" x 73½")... it'll pay to consult Ogilvie.

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"Quality and Service Since 1878"

OGILVIE PRESS, INC.
33 Rockwell Pl., Bklyn. 17, N. Y.

Please rush a free sample. Also, please quote on the enclosed.

Name.....
Title.....
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Address.....
City.....Zone.....State.....

Circle 546 on Page 19

to designers concerned with salability

CUSTOM ENGINEERED POWER BY WISCONSIN

FUEL SYSTEMS
Gasoline, natural gas, or LPG (for domestic use); and alcohol, kerosene, or No. 1 fuel oil (for export).

ELECTRICAL EQUIPMENT
Electric starter-generator system or electric starter only, for all models. Solenoid switches and automatic choke, for remote or automatic starting, also available.

HYDRAULIC POWER
All 4-cylinder Wisconsins can be equipped with integrally-mounted hydraulic pump.

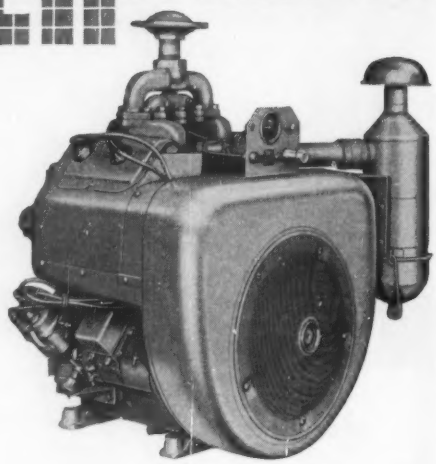
POWER DRIVES
Centrifugal clutch; over-center clutch; clutch reduction or reduction assembly in a variety of ratios; adaptor to take a spring-loaded clutch; or transmission-torque convertor designs.

DIRECT DRIVES
Special crankshaft extensions are available threaded, tapered, splined, special diameters and lengths, various keys, etc., for close-coupled pumps, generators, and other types of equipment.

SAFETY DEVICES
Low-oil-pressure cut-off switch for 2- and 4-cyl. models, and high-temperature safety switch for all models. Air cleaners, pre-cleaners, rotating screens, and removable shroudings for dirty operations.

SPEED CONTROLS
Manual, remote, wire-and-lever, and 2-speed idle-and-load; or provisions for controls of your own design.

OTHER ACCESSORIES
Automotive and spark-arresting mufflers, drive pulleys for flywheel, and rewind starters for ACN and BKN engines.



...offers many equipment options like these, to increase buyer acceptance of your product

Wisconsin engineers have at their fingertips a broad range of production-ready accessory options. Not only does this help you add sales-stimulating features to your product's power unit, it also provides an economical means of modifying your Wisconsin engine selection — both to your equipment's peculiar requirements and to anticipated service conditions.

Consult our engineers before you write your power drive specification — for basic unit design or equipment. Their recommendations can help you design for proved reliability — for assured salability of any engine-powered product.

Bulletin S-249 gives technical details on the complete Wisconsin line. Write for your copy today. Address: Dept. O-10.

O-150

WISCONSIN MOTOR CORPORATION
MILWAUKEE 46, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

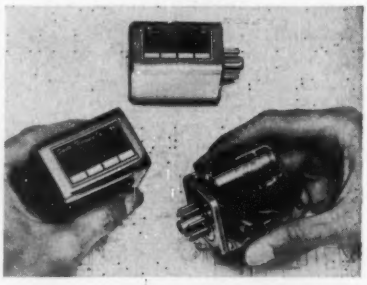
and range in capacity from 15 to 80 gpm. **Hydraulic-Electronic Div., Fawick Corp.**, 9919 Clinton Rd., Cleveland 11, Ohio.

Circle 774 on Page 19

Power Supplies

are miniature, solid-state units

Miniature solid-state, high-voltage power supplies are available in two series. From a 12 or 28-v dc input, outputs from 400 to 2000 v dc at 20 mu amp are provided. Second series furnishes a 28 or 12-v dc output at 100 ma from a 117-v ac source. Dimensions are $1\frac{5}{8}$ x $1\frac{5}{8}$ x $2\frac{3}{8}$ in. All supplies are equipped



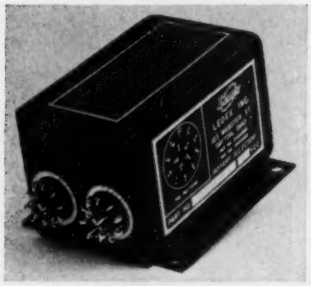
with a standard octal plug for simplified mounting. Regulation is 1 per cent no load to full load, and maximum voltage shift is ±1 per cent from 0 to 55 C. **Smith-Florence Inc.**, 4228 23rd West, Seattle 99, Wash.

Circle 775 on Page 19

Selector Switches

line includes eight voltage ratings

Series 150,000 hermetically sealed selector line includes 3072 switches with eight voltage ratings from 6 to 240 v dc. Sealed units provide six different electrical positions. Primarily intended for remote switching functions, six varieties of stepping and selective controls are available. Designs meet shock, vibration, temperature, corrosion, and acceleration requirements of MIL-E-5272. Units can be provided with either pigmy connectors or solder-type headers. Completely protected from dust, humidity, altitude, fungus, and salt spray, selectors provide a variety of switching functions. Compact size makes them ideal for



limited-space applications. **Ledex Inc.**, 123 Webster St., Dayton 2, Ohio.

Circle 776 on Page 19

Vinyl-Chloride Resin

for heavy-gage sheeting

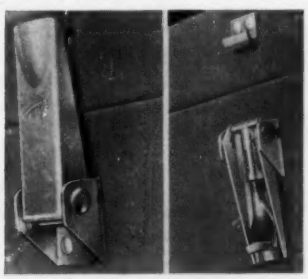
Pliovic BL-80 is a cold-blending or blotter-type resin. It can be preblended at room temperature, and absorbs high amounts of plasticizers to form a relatively dry, free-flowing mixture without heating. In addition to plasticizer absorption and freedom from gel particles, vinyl shows improved calendering properties. **Chemical Div., Goodyear Tire & Rubber Co.**, Akron 16, Ohio.

Circle 777 on Page 19

Container Latch

for light-duty use

Adjustable container latch is designed for light-duty use on reusable shipping containers, transit cases, and component assemblies. It has an adjustable drawhook which stows flat within the handle when latch is fully open. Adjustment is made by rotating the hook section; range of adjustment is 0.30 in. in vernier increments of approximately 0.02 in. per turn. Overcenter toggle geometry, built into the latch, prevents it from springing open due to movement of container sections which may be caused by shock, vi-



HOW THE SILICONES MAN HELPED AMERICA KEEP ITS DATE WITH THE JET AGE

As your jet air liner streaks aloft today, UNION CARBIDE Silicones are aboard to help. Silicones aided in its manufacture, too. The giant tires GOO slipped easily from their original molds because of silicone mold release agents. Polyether foam seat cushions were formed under the near-ideal control of silicone surfactants. Soft, flexible oxygen masks, of oxygen-and-ozone-resistant silicone rubber, fit facial contours without irritating the skin. Silicone fluids damp out vibration in vital, sensitive instruments. Silicone rubber door seals never lose resiliency even in extreme temperatures, won't harden or shrink. This constant flexibility makes it the basic material in blankets used for construction of honeycomb structural panels, also in grommets, gaskets, and O-rings. And in the flexible hoses in hot-air jet-engine starters. You'll find jet aircraft radio and radar wires insulated with electrically resistant silicone rubber. Piston plane and helicopter ignition wiring, too. Also the boots for helicopter control sticks, many other parts. This is only a smattering of what silicones have been doing for just one industry—aviation. Is your business enjoying equal benefits? We suggest you contact the UNION CARBIDE Silicones Man. Address: Silicones Division. Dept. LL-0002, Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y.

Unlocking the secrets of silicones

Rubber, Monomers, Resins, Oils and Emulsions

UNION CARBIDE **SILICONES**

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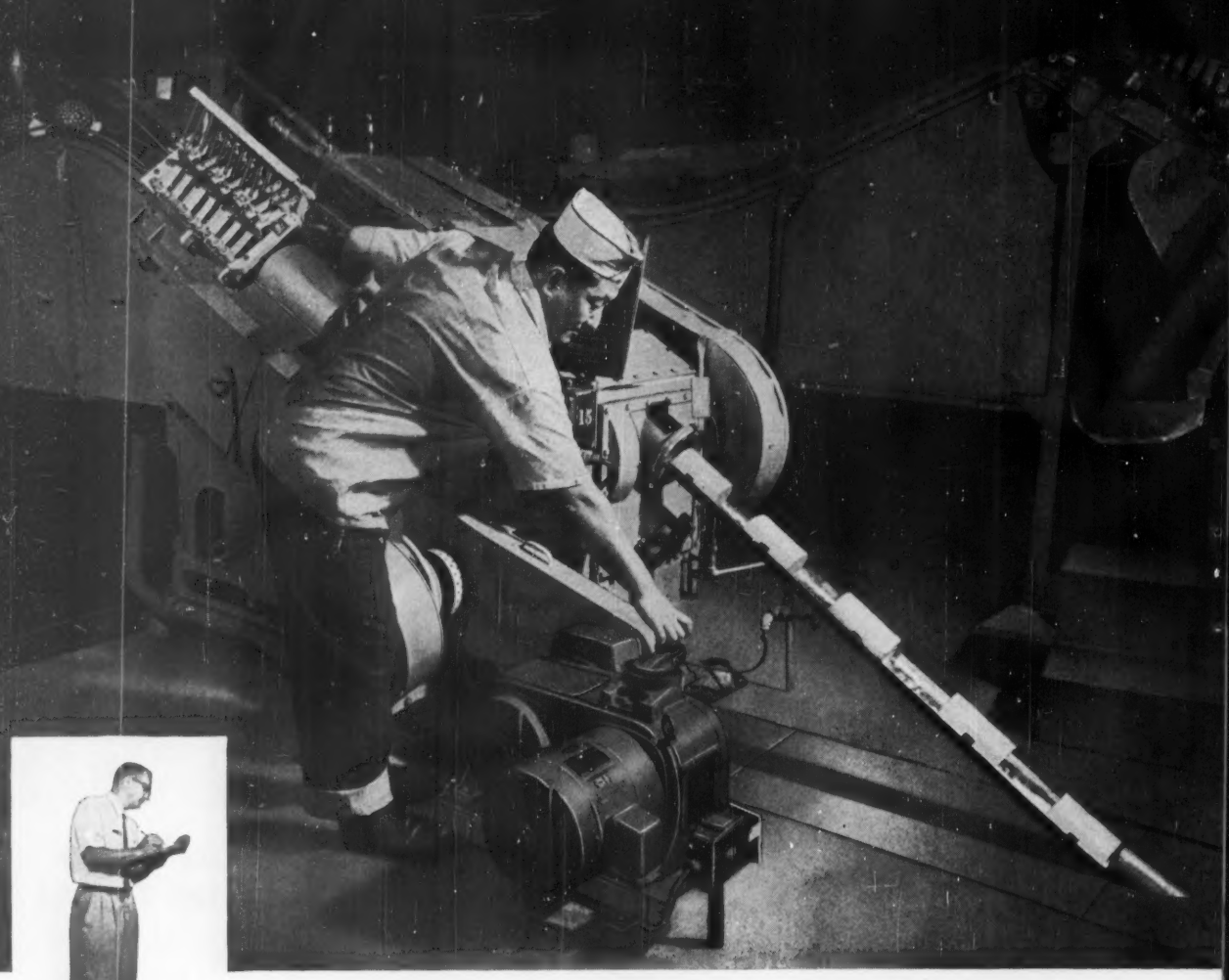


Mr. R. A. Weaver, Electrical Superintendent,
Dole Hawaiian Pineapple Company states: **"On the basis of evaluation and comparison with other drives...**

We found General Electric Polydyne® Drives best meet our adjustable-speed requirements."

At Dole Hawaiian Pineapple Company's Honolulu Cannery, "Ginaca" processing machines can automatically reduce whole pineapples into separate "components" of core, rind, pulp and a cylinder ready for final processing at a rate of up to 6000 per hour. With a constant-speed motor drive it is necessary to stop and start a Ginaca to control output. However, the Polydyne Drive can match the varying conditions at each stage of the processing system. The adaptability of Polydyne Drives reduces the need for supervisory attention and permits maximum processing efficiency.

Dole Company personnel selected General Electric's Polydyne Drives for the quick and smooth response to speed adjustments demanded by their continuous processing system. As Mr. Weaver also commented, "In our evaluations and comparisons with other drives we gave particular attention to ease of belt replacement because this makes maintenance simple and reduces downtime. We found Polydyne Drives far superior to other drives for making belt changes quickly."

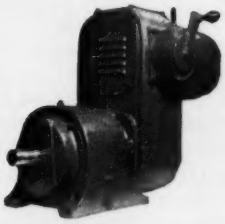
When your application requires low-cost adjustable speed combined with reliability and ease of maintenance, investigate G-E Polydyne Drives. Your General Electric Sales Engineer has full details. Or, write for bulletin GEA-6806, Section 854-05, General Electric Company, Schenectady 5, N. Y.

GENERAL ELECTRIC

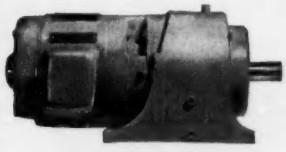
Circle 549 on Page 19

GENERAL ELECTRIC OFFERS A *COMPLETE* LINE OF LOW-SPEED DRIVES 1/8 TO 200 HP

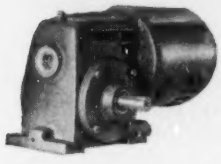
Select from G.E.'s PLUS LINE of compact mechanical power transmission equipment! A full range of ratings is available—many directly from stock.



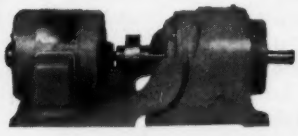
General Electric Polydyne Drive



Integral-type Gear Motor

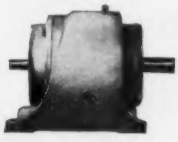


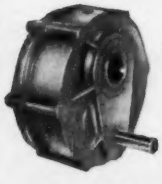
Right-angle Shaft Gear Motor



All-motor Gear Motor

Footed Speed Reducer





Shaft-mounted Speed Reducer

Member of American Gear Manufacturers' Association

GENERAL ELECTRIC

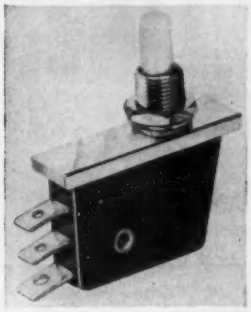
bration, or misalignment. Provision can be made readily for security wiring. **Camloc Fastener Corp.**, 37 Spring Valley Rd., Paramus, N. J.

Circle 778 on Page 19

Snap Switch

features 3/8-in. overtravel

Designed to solve space-limitation problems and offer increased flexibility in engineering tolerances, new snap switch has many advantages in a wide variety of applications. Total plunger travel is 1/2 in., of which a full 3/8 in. is overtravel. Both SPDT and SPST versions of the switch are available with a snap-in bezel for front mounting or threaded bushing (shown) for back mounting. Heavy-duty construction and coin-silver contact en-



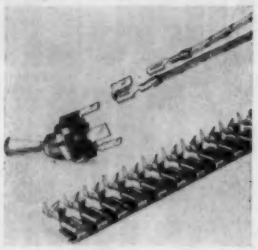
sure long life under heavy work loads. All terminations are located at one end. Unit is UL approved for 10 amp, 125 v ac or 5 amp, 250 v ac. **Ucinite Co., Div., United-Carr Fastener Corp.**, Newtonville 60, Mass.

Circle 779 on Page 19

Quick-Connect Terminal

provides multiple connections to the same terminal

New double-duty, quick-connect terminal simplifies wiring of electrical equipment by providing multiple connections to the same terminal. Basically, it is a female connector for attachment to male terminals normally furnished on many switches, timers, motors, sockets, relays, solenoids, transformers, and junction boards. Connector also incorporates an integral male terminal to which another female connector or double-duty connector can be attached. Connector is heavy-gage brass to meet UL requirements for mechanical strength and electric



current rating. Crimp-on section accommodates No. 18 to No. 12 wires with normal insulation. Connector is available individually or in continuous strips for automatic attachment. **Ark-Les Switch Corp.**, 51 Water St., Watertown 72, Mass.

Circle 780 on Page 19

Base Paper

has no organic binders

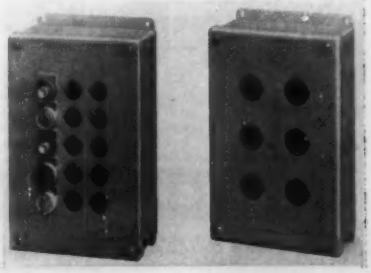
Style 7601S Novabestos base paper is an asbestos and silicone resin paper, with no organic binders of any kind. Material is suitable for operation at Class-C temperatures. Electrical properties are not impaired by exposure to 275 C for 450 hr. Paper is available in gages from 0.0025 to 0.0065 in. **Asbestos Textile Div., Raybestos-Manhattan Inc.**, Manheim, Pa.

Circle 781 on Page 19

Sheet-Steel Boxes

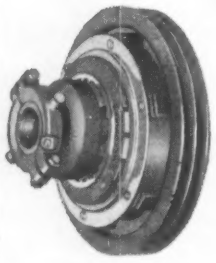
for miniature, oiltight pushbuttons

Sheet-steel boxes for new miniature oiltight pushbuttons are available in ten standard enclosure sizes with from 2 to 49 pushbutton holes. As shown, 15 miniatures can be used in the enclosure size used for six conventional buttons. Boxes are 14-gage steel and are completely oil and dusttight. Covers have neoprene gaskets, and captivated cover screws thread into sealed wells in



DISCERNING DRAFTSMEN THE WORLD OVER DEMAND IMPERIAL THE WORLD'S FINEST TRACING CLOTH

Circle 551 on Page 19



What Some Folks Won't Do to use a **CONWAY CLUTCH!**

TODAY . . .

we look at the Conway Sleeve Sheave Clutch (illustrated) and think of all the work we must do so it will fit our jobs.

IN THE OLD DAYS,

folks looked at the same Conway Sleeve Clutch and thought of how much work it would save. Do you know that some of those old-timers put the flat belt right smack-dab on the hub! Now, that's downright miserly.*

*Anyone for penny-pinching?

Hence, if you're averse to work—you know, like cutting keyways and mounting sheaves, gears and sprockets—JUST LET US DO IT. We, at Conway Clutch, are crazy about it (Work, we mean.)

Write us and ask about integrated clutches.

The CONWAY CLUTCH COMPANY

2750 Colerain Ave. Cincinnati 25, Ohio

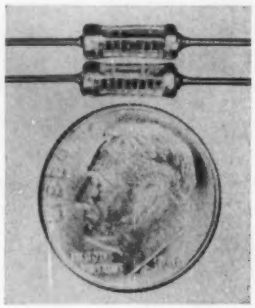
the bodies. Conduit connections can be made anywhere on the four sides or back. Standard finish is gray hammertone enamel over a phosphatized surface. **Hoffman Engineering Corp.**, 889 Tyler St., Anoka, Minn.

Circle 782 on Page 19

Carbon Film Resistor

provides ¼-w dissipation in ⅛-w package size

Hermetically sealed, hard-glass carbon film resistor provides a wattage rating double the standard MIL specifications for the same size package. In addition to guaranteeing ¼-w dissipation from a package meeting the MIL-R-10509C dimensions for ⅛-w resistors, device features excellent mechanical strength. Hard-glass case has high resistance to thermal shock. It cannot suffer case damage from lead tension. **Semiconductor - Components Div., Texas Instruments Inc.**, P. O. Box 312, Dallas 21, Tex.

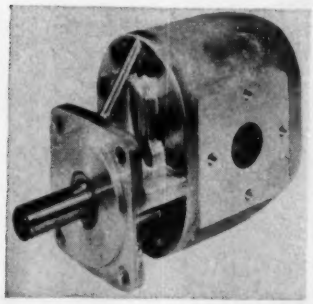


Circle 783 on Page 19

Gear Pumps

have speeds to 2800 rpm

Pressure - balanced GPA3 gear pumps have speeds to 2800 rpm and flow rates to 60 gpm. Speed range permits operating at mobile-equipment engine speeds. Continuous pressures to 2250 psi are acceptable, and operating temperatures may reach 250 F with minimum oil viscosity of 55 ssu. Pumps can be coupled to the prime mover or driver through belts or gears. Pressure-balanced, self-compensating design employs discharge pressure to maintain an optimum counterbalanced thrust of the journal bearing toward the gear faces to con-



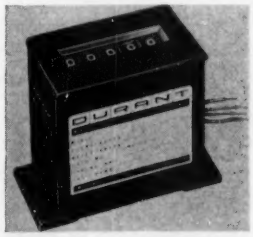
trol leakage and wear, resulting in excellent volumetric efficiencies. Pressure lubrication independent of discharge pressure assures true journal-bearing life. Berry Hydraulics Div., Oliver Tyrone Corp., Corinth, Miss.

Circle 784 on Page 19

Electric Counters

are high-speed units

YE Series redesigned electric counter is now finished in neutral instrument black. It has a high-speed drive internal mechanism that permits it to run well over conservatively rated 1500 cpm without fear of mechanical breakdown or error. Case is also sealed against dust and splashing. Four models provide long count life, reset life, and continuous or intermittent duty. They count accurately at high, low, or intermediate speeds as conditions demand. Large 3/16-in. white figures stand out clearly on black



background. Durant Mfg. Co. 1933-IS N. Buffum St., Milwaukee 1, Wis.

Circle 785 on Page 19

Rotary Actuators

in five sizes with torques from 1500 to 702,000 lb-in.

Hydraulic rotary actuators for commercial use, called Hyd Ro-Ac, are furnished in five different sizes.

Passage or control of air, sound, light or fluid . . . decorative concealment . . . component protection . . . eye catching, sales-building beauty—if your product requires any or *all* of these features, you'll find the design and functional versatility you need in the Harrington & King line of perforated materials. Just four of H & K's new patterns are illustrated here. There are many more contemporary and traditional designs, all available in steel sheets for shipment from stock.

And there is also a vast selection of additional patterns and open areas which can be custom fabricated from existing dies. H & K can perforate practically any material. May we put our more than 75 years of experience to work for you?

FIND NEAREST H & K AGENT IN THE 'Yellow Pages'
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Send for Catalog 75 and/or Stock List including new patterns

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New York 6, N. Y.

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Please send me: ☐ GENERAL CATALOG No. 75
☐ STOCK LIST of Perforated Sheets

NAME_____
TITLE_____
COMPANY_____
STREET_____
CITY_____ ZONE____ STATE_____

Circle 553 on Page 19

motors like these help your product STAY AHEAD of competition...

Lamb® series motor with two-stage fan — the standard for high performance domestic canister-type cleaners.

Lamb® three-stage gearmotor incorporates special brackets, reversing switch and connecting cord for pipe threader. Frame 4⅜ x 2¼.

Lamb® induction gearmotor with special quiet operating three-stage gear train and magnetic brake for rotary office file. Frame 4½ x 2⅜.

Lamb® four-pole split phase motor with resilient cradle base for business machines. Frame 4½ x 2¼.

Lamb® six-pole 400cycleACmotor for operation submerged in jet fuel for booster pump drive. Frame 2⅞ x 2½.

Lamb Electric works in so many fields — where motors that have vastly different jobs to do are sold to vastly different markets — that experience gained in one field often helps solve problems in other fields.

For example, we are able to incorporate in motors for appliances, portable electric tools, and similar products, developments that came about in research and engineering work on military and other precision motors.

This broad experience — available to all of our customers — is one way in which Lamb Electric special application motors can help your product stay ahead of competition.

Let us demonstrate the value of this experience in bringing to *your customers* improved products and to *you* more business and better profits.

THE LAMB ELECTRIC COMPANY • KENT, OHIO

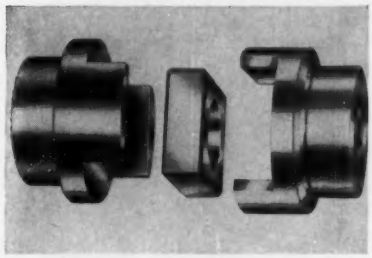
A Division of American Machine and Metals, Inc.
In Canada: Lamb Electric — Division of Sangamo Company Ltd. — Leaside, Ontario

WRITE FOR YOUR COPY

8-page folder describes these and other Lamb Electric motors.

Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Circle 554 on Page 19



Torque range is from 1500 to 702,000 lb-in. at 3000 psi, and operating pressure ranges from 250 to 3000 psi. Units have an efficiency of 95 per cent or over, with low starting (friction) torque. They provide angular travel to 280 deg and can be foot or end mounted. **Buffalo Hydraulics Div., Houdaille Industries Inc.**, Dept. Z, 537 E. Delavan Ave., Buffalo 11, N. Y.

Circle 786 on Page 19

Flexible Coupling

has center which retains lubricating oil

New flexible coupling utilizes an oil-impregnated center member of sintered steel. Through capillary action, center member absorbs and retains high-grade lubricating oil for long periods and dispenses it to bearing surfaces as needed. Unit maintains all misalignment capacity characteristics inherent in standard American jaw flange flexible couplings, and has greater torque

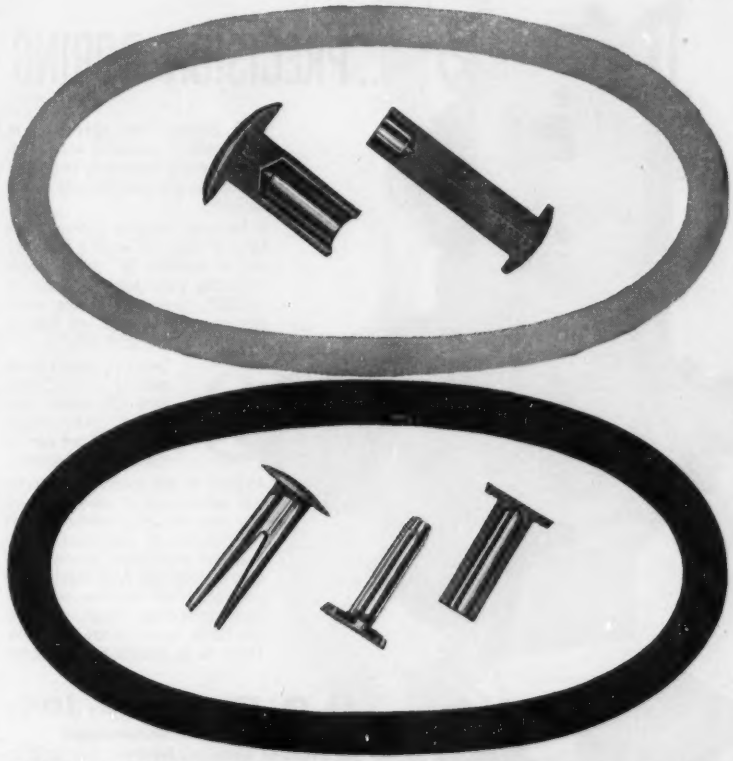
and load-carrying capacity. **Mechanical Power Transmission Div., Zurn Industries Inc.**, Erie, Pa.

Circle 787 on Page 19

Pressure Switch

has accuracy of ½ per cent

Precision pressure switch for absolute, differential, or gage pressure is designated Model 400100. It offers an accuracy of ½ per cent and



COST PREVENTION...NOT COST REDUCTION...IS THE EFFICIENT WAY TO LOW-COST ASSEMBLY

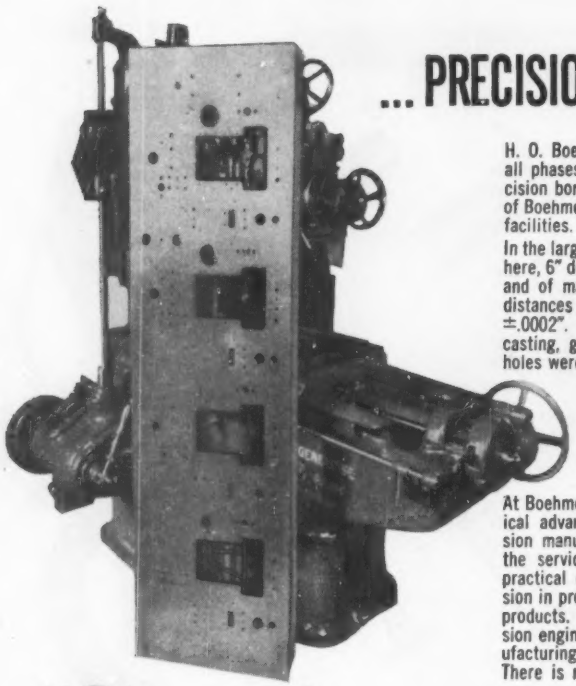
The "in-place" cost of a fastener is what really counts to cost-conscious design engineers. By deciding on inexpensive Milford tubular rivets as a fastening method and installing them with Milford automatic rivet-setting machines, design and production engineers are eliminating costs at the initial production stage rather than trying to reduce costs later at the assembly line.

You can find out more about Milford's cost-cutting ideas by asking your Milford Representative to show you Milford's new MANUAL OF MODERN RIVETING PRACTICE. It's crammed with valuable cost-cutting tips and technical data that can be quickly translated into dollars on your production line.

THE MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • NORWALK, CALIFORNIA
ELYRIA, OHIO • AURORA, ILLINOIS • HATBORO, PA

Circle 555 on Page 19



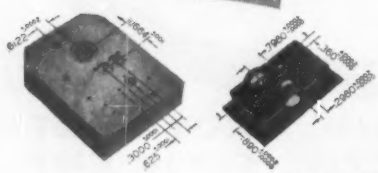
...PRECISION BORING

H. O. Boehme, Inc., specializes in all phases of precision work. Precision boring represents one facet of Boehme precision manufacturing facilities.

In the large, complex casting shown here, 6" deep, 20" wide, 6 feet long and of material ⅜" thick, center distances were held to limits of ±.0002". (Similarly, in the small casting, gear centers and line up holes were held to ±.0002".)

Swiss jig borers accurate to ±.0001", rotary tilt tables and other specialized equipment are part of our modern facilities.

At Boehme you obtain the economical advantages of modern precision manufacturing methods, plus the services of craftsmen whose practical experience assure precision in prototype or production-run products. Your inquiries on precision engineering, design, and manufacturing services are welcome. There is no obligation, of course.



H. O. Boehme, Inc.

Contractors, Designers, Manufacturers of Precision Electrical, Electro-Mechanical and Electronic Equipment since 1917

915 Broadway New York 10, N. Y.

Circle 556 on Page 19

NEW! FROM UNITED

Metallic O-Ring Retainer Plates cut machining and assembly costs!

Now mating flanges can be sealed without machining grooves to hold metallic O-rings! United's metal retainer plates can be made for most junctures, regardless of the number of ports.

Openings in retainer plates function the same as groove walls. They furnish O-ring compression limit, control O-ring hoop tension, position O-rings for accurate matching of multiple hole patterns in mating flanges, and permit interchangeability of flanges. For price quotations, send flange drawing and specifications for fluids, pressures and temperatures to:

UNITED METALLIC "O" RINGS
manufactured by
United Aircraft Products, Inc.
Box 1035 Dayton, Ohio

Circle 557 on Page 19

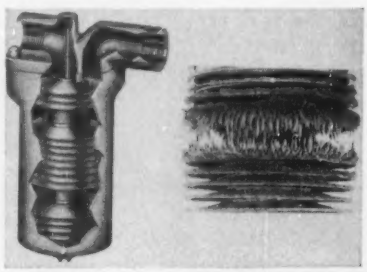
is available in any pressure setting from 0.2 to 250 psi. Wide band of adjustment is provided for a given nominal switch pressure. Switch performs reliably without loss of accuracy under 40 g vibration environment. Basic design of the switch isolates contacts from pressure-sensing cavities to provide compatibility with any medium, liquid or pneumatic. Materials compatible with liquid oxygen are used in the pressure cavities on the standard unit. **Wallace O. Leonard Inc.**, 373 S. Fair Oaks Ave., Pasadena, Calif.

Circle 788 on Page 19

Magnetic Line Strainers

trap small particles from 0.003 to 0.005 in.

Magnetic line strainers meet JIC specifications for magnets in hydraulic systems and are suitable for use on all types of equipment. They can be adapted quickly for existing systems where sump strainers cannot be used. Concentrated, two-way filtration comes from powerful, built-in circular Alnico magnets placed between removable filter disc screens at specific intervals. Screens remove nonmagnetic matter and the rest of the unit traps magnetic particles. Strainers trap small particles from 0.003 to 0.005 in. When disassembled, iron and metallic filings drop off disc covers for quick, easy cleaning. Units are available in a wide range of stand-



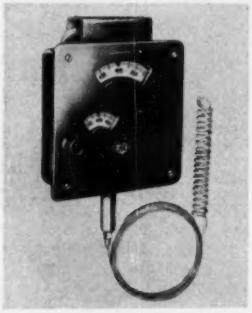
ard and special sizes. **Filter Div., Ripley Screen & Strainer Co.**, 32749 Northwestern Highway, Farmington, Mich.

Circle 789 on Page 19

Temperature Control

for temperatures from −150 to +650 F

E32NA dual-switch indicating temperature control is suited for such applications as ovens, baths, environmental test chambers, molding machines, and plant processes. It features a calibrating mechanism which makes possible easy replacement of thermal assembly in the



field with no loss of calibration accuracy. Unit operates over a temperature range of −150 to 650 F. Standard electrical rating is 15 amp, 115/230 v ac, with many types of switches and other ratings available. **United Electric Controls Co.**, 79 School St., Watertown 72, Mass.

Circle 790 on Page 19

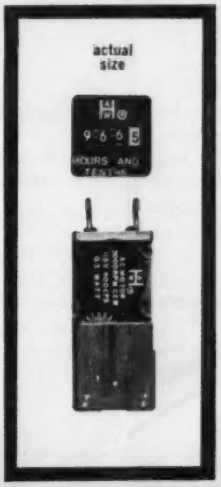
Ball Valves

in ½ to 2-in. sizes

Compression-mounted ball valves are available for the chemical processing, pulp and paper, nuclear marine, and missile industries. Furnished in ½ to 2-in. sizes, valves are supplied with through-bolts for mounting between existing flanges. They can be disassembled or assembled rapidly. Valves are rated at 1000 psi cold nonshock service and 300 psi at 400 F. Full port opening of valve eliminates turbulence, and adjusting shims prolong life of broad Teflon seats. Positive, rectangular, slotted key drive in the ball eliminates ball and stem

PLEASE DON'T SWALLOW OUR MOTOR

...IT'S HIDING BEHIND THE ASPIRIN. Actually, we set out to build an easy-to-read tiny timer... but we first had to build an aspirin-sized motor to drive it. This assignment might have been a headache for a sorcerer, but A. W. Haydon did it. And there is something magical about these miniature elapsed time indicators and companion events counters. ■ This digital elapsed time indicator has many outstanding features: size is only ½" square x 1 1/16" long... weight .75 ounce...



meets all mil specs... temp. range −54 to +125°C... vibration to 2000 cps at 20 G... choice of two ranges (hours to 9999, tenths to 999.9)... power input .5 watt, max. In fact, the complete data outweighs the equipment. Send for our heavyweight literature on the 19200 ETI right now. ■ Electrical or electronic, the A. W. Haydon Company works wonders in time. For electronic requirements call Culver City. For electromechanical devices call on our wizards in Waterbury.

THE AWH HAYDON COMPANY
249 NORTH ELM STREET, WATERBURY 20, CONNECTICUT

Circle 558 on Page 19

NEW SERIES of Antenna SLIP RING Assemblies

12 to 500 RINGS

A standardized line of large Slip Ring assemblies, designed for a multiplicity of instrumentation, control and power circuit applications. First production assemblies are in use on radio telescopes, radar and tracking antennas and human centrifuge installations.

Assemblies vary from 12" to 72" in length, are either shaft or flange ball-bearing mounted and may be specified with hermetically sealed housings. Noise levels are held to a minimum. So are intercircuit losses, cross-talk and radiation, through proper shielding.

For complete information, write:

SCA

SLIP RING COMPANY of AMERICA

3612 West Jefferson Blvd., Los Angeles 16, Calif.

Circle 559 on Page 19

wear, ball wobble, and assures positive rotation. Equal flow can be achieved in either direction. **Cooper Alloy Corp.**, Hillside, N. J.

Circle 791 on Page 19

Carriage Bolts

have tensile strength over 130,000 psi

Line of carriage bolts has a tensile strength of over 130,000 psi compared to 55,000 psi for other bolts. Bolts stand up under high stress conditions in such applications as conveyors, snow plows, textile machinery, marine applications, and lawn mowers. Bolts overcome the problems of head-popping, shearing, and stretching. Use of quality high-carbon steel, triple heat-treated, gives maximum strength, toughness, and durability. Bolts are impregnated with Resisto-Plate for long lasting resistance to rust and corrosion. **Premier Industrial Corp.**, 4415 Euclid Ave., Cleveland 3, Ohio.

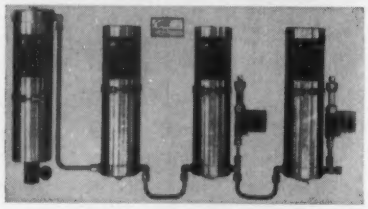
Circle 792 on Page 19

Electronic Timer

is subminiature, transistorized unit

TR-302 subminiature transistorized electronic timer has a wide range of selection in timing ranges and physical mounting. Standard units are plug-in with double-pole, dou-

When water or oil in gases cannot be tolerated . . .



INSTALL ROBBINS dehydration equipment

Robbins Aviation offers you both disposable cartridge type and refrigeration type dehydration systems for practically all types of gases . . . equipment designed and built to rigid quality control standards to give you maximum satisfaction in efficient trouble-free performance.

Robbins equipment is used extensively for aircraft pneumatic systems, test laboratory equipment, mobile compressor trailers, hydraulic system purging, missile charging and pressurizing systems, for instrument, laboratory, and factory air, controlled atmospheres for brazing and heat-treating furnaces, etc. Mechanical filters, drier and purifier chambers, refillable and disposable cartridges, dewpoint indicators also available.

Fast, positive, economical removal of water or oil vapor and impurities

Pressures to . . . . . 12,000 PSI
Safety Factor . . . . . 4 to 1
Dewpoints to . . . . . −100°F
Oil Vapor Removed to . . . as low as 0.3 ppm/w

Write today for complete information!

ROBBINS Aviation Inc.

Manufacturers of high quality valves and dehydration equipment

2350 E. 38th St., Los Angeles 58, Calif.
LUdlow 9-5221

Circle 560 on Page 19

size is no problem!

The bigger your tubular steel problem – the better we like it! Why? Because with all our modern facilities "under one roof," we are completely equipped to handle a variety of difficult jobs – expertly and economically! For expert consultation on centrifugally spun tube applications in your field... call on ACIPCO.

VERSATILE ACIPCO CENTRIFUGALLY SPUN STEEL TUBES

SIZE RANGES: Tubes are produced in lengths from 4′ to 20′; longer lengths are made by welding. O.D.'s from 2.25″ to 50″ — wall thicknesses from .25″ to 8″.

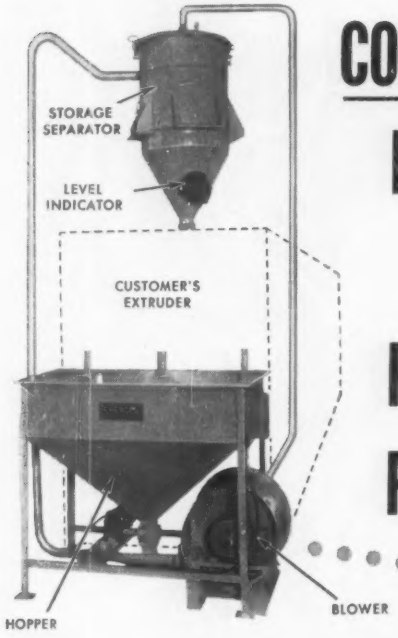
ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steels, plain carbon steel and special non-standard analyses.

FINISHES: As cast, rough machined, or finish machined, including honing and grinding. Complete welding and machine shop facilities are available.

Write for FREE Illustrated Catalog.

ACIPCO
SPECIAL PRODUCTS
DIVISION OF AMERICAN CAST IRON PIPE CO.
BIRMINGHAM • ALABAMA

Design Problem Here Was



CONTINUOUS FEEDING OF PLASTIC PELLETS

SPENCER Blowers Provided the Solution

This designer's problem was to find a means of *automatically* feeding plastic pellets into extruders—*continuously*. A *closed* system was necessary to prevent contamination of material with atmospheric dust and to prevent escape of plastic "fines".

A Spencer blower, incorporated with the customer's equipment as shown, solved the problem. Pellets in hopper are gravity fed through a rotary valve into the air stream, then conveyed up to the storage separator as required.

When level indicator registers sufficient drop in level, another quantity of pellets is fed from the bin into the extruder.

Spencer will be glad to assist in adapting standard blowers or vacuum producers—or designing special units—to meet *your* particular needs.

Two Catalogs to Aid the Designer

"132 UNUSUAL USES OF SPENCER VACUUM"
Bulletin 144 illustrates and describes how Spencer Vacuum is used in industries from A to Z.

"TURBO DATA BOOK"
Supplies application data on Spencer Blowers. Request Bulletin 107-C.

STANDARD CAPACITIES
of Spencer Blowers
⅓ HP to 1,000 HP
Up to 20,000 CFM
4 oz. to 10 lbs. pressure

The SPENCER TURBINE COMPANY
HARTFORD 6, CONNECTICUT

Circle 562 on Page 19

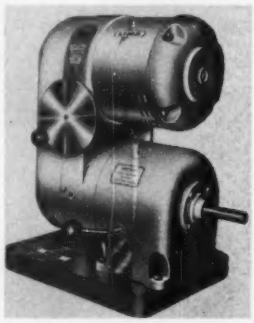
ble-throw, 5 amp resistive contacts. Model operates on 115 v ac. Unit is unaffected by voltage, temperature, and line transient. **Syracuse Electronics Corp.**, P. O. Box 566, Syracuse 1, N. Y.

Circle 793 on Page 19

Variable-Speed Drive

incorporates new four-speed transmission

Vari-Gear drive incorporates a four-speed transmission, resulting in three times greater torque at the low speed than in comparable friction-type units. When an 1800-rpm motor is incorporated, every rpm between 180 and 1800 is ob-



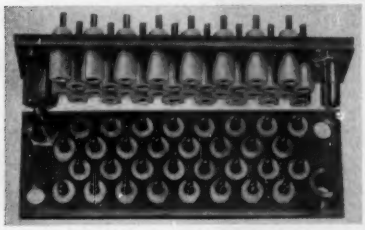
tainable from the unit. Using a 1200-rpm motor, all speeds between 120 and 1200 are available. Either dripproof or totally enclosed, fan-cooled units can be furnished in ½, ¾, or 1 hp. Simple control wheel regulates the output shaft to the desired rpm. A pointer indicates on a calibrated speed plate the exact rpm at which the output shaft is turning. **Lima Electric Motor Co. Inc.**, Dept. 139, Lima, Ohio.

Circle 794 on Page 19

Rack and Panel Connector

incorporates 32 Teflon-insulated terminals

New rack and panel connector, Model 32T, shows extremely low losses under environmental conditions of temperatures to 200 C, humidity, and salt spray. Because of high heat-handling capabilities, connector has applications in the missile, avionic, and ground-support equipment field, as well as for reliability test lab purposes. Low contact resistance is achieved by



use of identically machined face and back terminal mount plates, identical OD male and female Teflon compression-mount terminal holders, and use of gold plating to 0.0001-in. thickness on mating surfaces of terminals. Male guide pins and female guide sockets are used for quick alignment of connectors. Connector has four rows of eight terminals each. Unit is 1.25 in. high and 3.9375 in. wide. **Jupiter Electronics Inc.**, 225 E. 144th St., New York 51, N. Y.

Circle 795 on Page 19

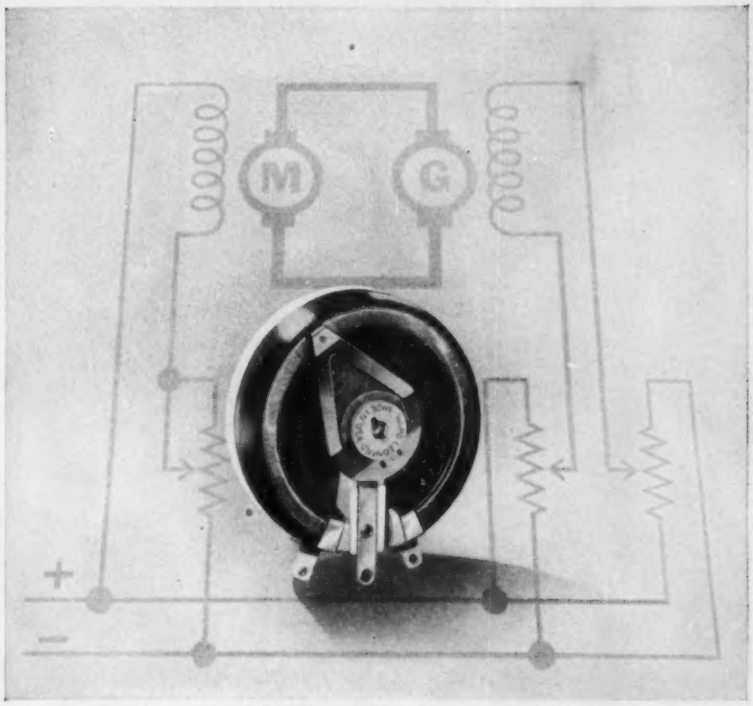
Positioning Control

is used in conjunction with various power mechanisms

Electrical-mechanical servo device, Powr Positioner, automatically positions machine tools, valves, float levels, doors, and hopper-gates at any of several predetermined positions. Unit is used in conjunction with various types of power mechanisms such as an air or hydraulic cylinder, along with solenoid valves applied to operate a pipeline flow valve. Model PR2A has two cam rods, and a connecting link on one end is attached to the mechanism the positioner is controlling. Other two ends of the steel cam rods trip limit switches as the cam rods slide back and forth inside two

channel grooves in the extruded-aluminum positioner housing. There can be as many as 14 sets of limit switches per ft. Positioner is available in various lengths up to 8 ft as standard. Unit achieves accuracies of ±0.005 in., depending upon mass and weight of load or type of applications. It is not de-

(*Please turn to Page 260*)



Background is schematic of world-famous Ward Leonard system of control.

In modern rheostat circuits, it's

SERVICE CONTINUITY THAT COUNTS

Production stopped. Workers idle. But wages, maintenance costs, and fixed charges go merrily on accumulating.

That's the black picture when an industrial control component—specifically a rheostat—fails. That's why reliability is more important than initial cost. In many cases, these irrecoverable charges and costs can quickly far exceed the replacement cost of the faulty components.

And that's why far-sighted designers are more and more specifying Ward Leonard VITROHM ring rheostats for control circuits where performance is a must... in motor and generator field control circuits... for electronic tube filament circuits... wherever substantial amounts of power must be handled with utmost rheostat reliability.

Ward Leonard ring rheostats, in sizes of 25, 50, 100, 150 and 300 watts, feature W/L's exclusive "twin contact shoe" design. *Two* sintered, self-lubricating contact shoes minimize wear and assure uniform contact pressure, smooth operation, and maximum reliability.

Special alloy resistance wire—made to W/L's closely monitored specifications to assure highest stability and lowest practical temperature coefficient—is bonded permanently to ceramic core by Ward Leonard's own VITROHM vitreous enamel.

These are just a few of the reasons why VITROHM ring rheostats give you outstanding reliability in industrial control circuits. There are many more quality-engineered features than we can describe here—for instance, highest grade ceramic base and core, durably bonded tinned alloy terminals, and balanced beryllium copper contact arm. You'll find them all in Bulletin 60RR (and for powers above 300 watts, check W/L plate rheostats in Bulletin 60A). For your copy, and for a list of stocking distributors, write: Ward Leonard Electric Co., 58 South St., Mount Vernon, N.Y. (In Canada: Ward Leonard of Canada, Ltd., Toronto.) o.s

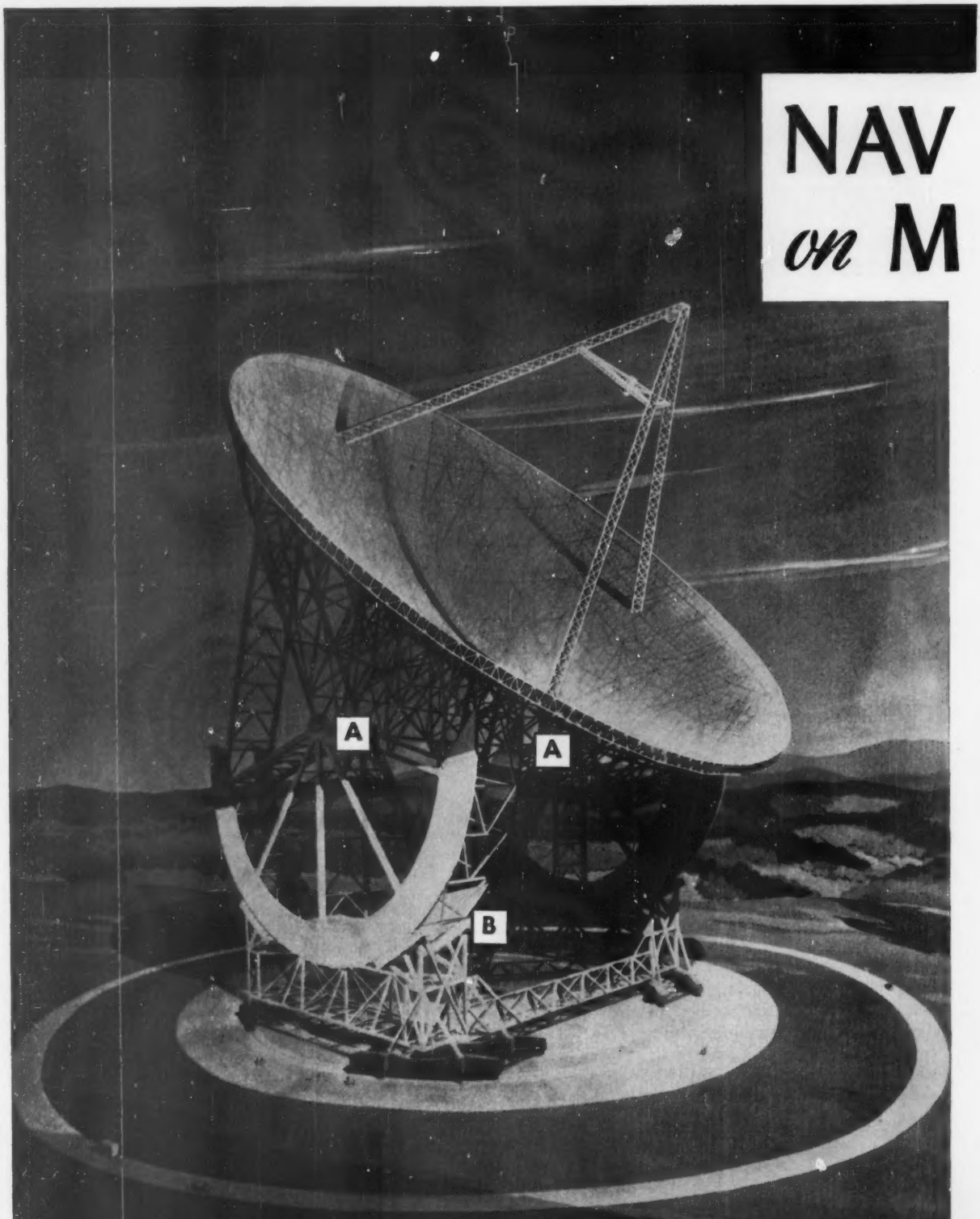
ELECTRONIC DISTRIBUTOR DIVISION

WARD LEONARD ELECTRIC CO. MOUNT VERNON NEW YORK

RESISTORS • RHEOSTATS • RELAYS • CONTROLS

Circle 563 on Page 19

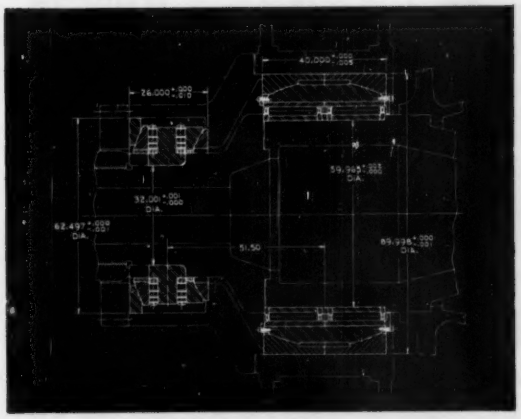
NAV *on* M



"BIG EAR", the U. S. Navy's 600' Radio Telescope, will enable scientists to see and hear objects in space thirty-eight billion light years away . . . nineteen times farther than with the telescope at Mt. Palomar, Calif. Messinger is proud to have such an important part in the operation of this largest of all space scanners.

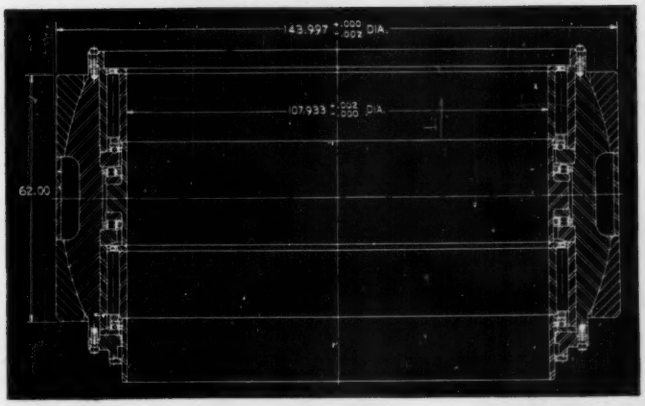
Y'S "BIG EAR" *will operate* ESSINGER BEARINGS...

CONSTANT PRECISION *in Scanning Motions of World's Largest Radio Telescope Assured by* MESSINGER *Engineering*



PORTAL BEARINGS . . . A

Two Messinger Combination Radial and Thrust Roller Bearings carry the load imposed by the horizon-to-zenith movement, each with the following dimensions: 32.001" I.D., 62.497" O.D., 26.000" WIDTH.



PINTLE BEARING . . . B

This main bearing assembly, on which the "Big Ear" rotates 360°, consists of the following:

Two Radial Roller Bearings, each 107.933" I.D., 121.497" O.D., 20.875" WIDTH.

One two-direction Thrust Roller Bearing 107.971"I.D.,121.497"O.D.,25.750"WIDTH, with Auxiliary Ball Thrust Bearings to carry the load of Radial Rollers and Separator.

All bearings assembled with Spherical Self-Aligning Adapters.

BIGNESS Merely Magnifies the Enduring Precision Engineered into Every Messinger Bearing.

If your new product or equipment, regardless of size or purpose, calls for bearings, early consultation with our Engineering Department may prove advantageous.

MESSINGER BEARINGS, Inc.

ROLLER AND BALL BEARINGS — FEATHERWEIGHT TO HEAVYWEIGHT

D STREET ABOVE ERIE AVE. • PHILADELPHIA 24, PA.

"Smoothing Industry's Pathway for Nearly Half a Century"

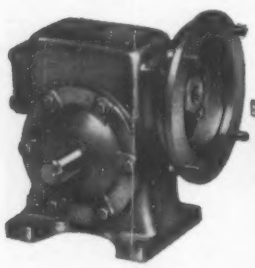
Circle 564 on Page 19

956

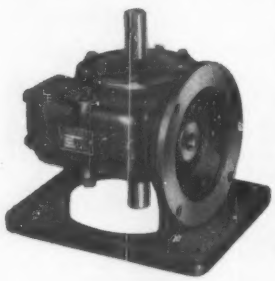
different
motorized
speed reducers

available from stock

Yes! 956 different combinations of Perfection Motorized Worm Gear Speed Reducers are available for immediate delivery, *from stock.* Ratios range from 5 to 1 to 60 to 1, in capacities from 1/6 H.P. to 5 H.P. Perfection "C" Flange Reducers may be ordered complete with motor or without motor, to be used with a motor *of your own choice.*



Flanged motor reducers offer the maximum in compactness, rigidity and adaptability. Through the use of standard NEMA face mounted motors, complete interchangeability between motors is provided. Motor maintenance is possible without disturbing the drive and reducer. Motor assembly is fast and positive with no alignment problems.



Write for your free copy of our new 28 page catalog containing illustrations, charts and tables to help you choose the right Reducer for your particular application. Ask for Bulletin No. M-140.

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AMERICAN STOCK GEAR DIVISION
PERFECTION GEAR COMPANY, HARVEY, ILLINOIS

(*Continued from Page 257*)

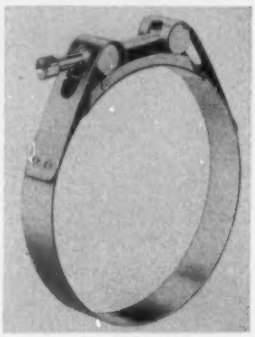
signed for extreme instrumental accuracies. **Hanna Engineering Works,** Dept. PR-26, 1765 Elston Ave., Chicago 22, Ill.

Circle 796 on Page 19

Band Clamp

for heavy-duty use

Type RM band clamp is designed for strong, heavy-duty applications in heating, ventilating, and air-conditioning systems and other commercial and industrial ducting applications on sleeves, air filters, and hose. Strap and bridge are 430



stainless steel, and nut, lug, and screw are cold-rolled steel, cadmium plated. Features of the clamp include ease of field assembly and simplicity of dismantling and reassembly of ducting. **Wittek Mfg. Co.,** 4305-43 W. 24th Place, Chicago 23, Ill.

Circle 797 on Page 19

Hydraulic Pumps

permit multiple circuitry in one unit

Two high-pressure, 90-hp hydraulic axial piston pumps are now available. Model PF 6033, at an operating speed of 1800 rpm, produces 22 gpm at 6000 psi. Model PF 3046 produces 29.5 gpm at 3000 psi and 1800 rpm. Pumps are for rugged duty where heavy shock loads are inherent with the system and flexibility is a prime factor. Both models feature "split-flow" which permits independent, multiple circuitry using a single pumping unit. Rotatable in either direction, pumps can be operated at speeds to 2400 rpm, maintaining

Circle 565 on Page 19

For the Design Engineer...

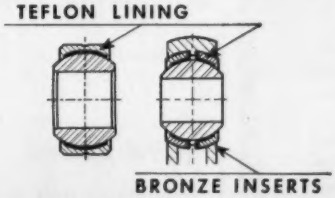
who desires plain self-aligning bearings which can withstand high loads and low speeds *without lubrication*

HEIM *Unibal*®

SPHERICAL BEARINGS

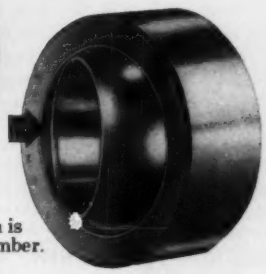
It is an established fact that the Unibal spherical bearing and the spherical bearing rod end have high load-carrying capacities. When a lining of Du Pont's "Teflon" is applied in such a way as to form the bearing surface around the ball, all the advantages of high load ratings, self alignment, and simplicity of assembly are retained. However, the long-wearing, low-friction, self-lubricating, high impact properties of the TFE fluorocarbon fiber are all "plus" advantages which open whole new areas of application possibilities.

Woven fabric of Teflon (TFE) fluorocarbon fiber is ideally suited, as a bearing surface, to applications where speed requirements are not severe and minimum torque is essential. Its waxy nature provides the self-lubrication which has made it possible for Unibal bearings to run continuously at moderate speeds for over a year without added lubricant.



After several years of engineering and testing, The Heim Company has developed a method of assembly which provides a securely locked, perfectly bonded lining.

Unibal Spherical Bearing
Stock Sizes to 1.750 O.D.



A layer of woven Teflon is bonded to the outer member.

Send for bulletin of complete list of sizes, load ratings and all data. See your Heim bearing distributor for further information.

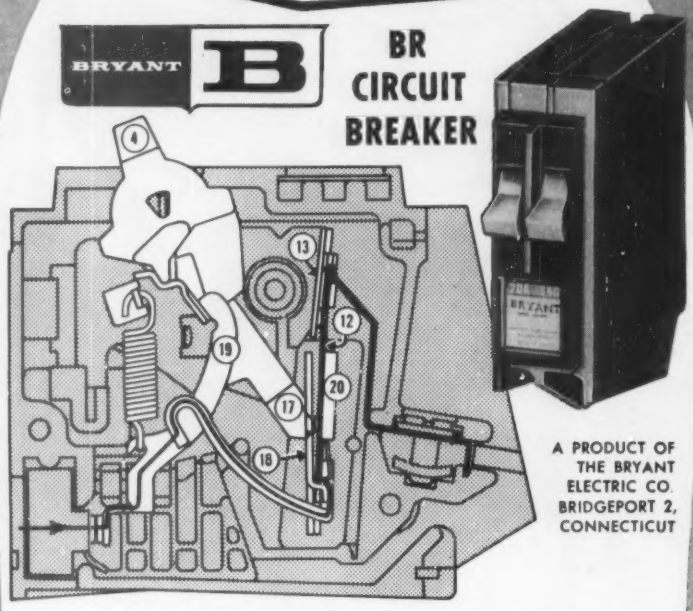
THE HEIM COMPANY
FAIRFIELD, CONNECTICUT

Chace Thermostatic Bimetal

ACTUATES ANOTHER PRECISION PRODUCT

BRYANT B

BR CIRCUIT BREAKER



A PRODUCT OF THE BRYANT ELECTRIC CO. BRIDGEPORT 2, CONNECTICUT

Interchangeability, compactness and sturdiness are three features readily apparent in Bryant's BR Circuit Breaker. The ***mounting dimensions*** make it interchangeable with five other makes; there are ***two*** breakers in the space formerly used for one; the mechanism is supported and enclosed by a husky ***metal frame*** and is completely independent of the insulating case.

Not so readily apparent is the "heart" of the BR Breaker. The all-important thermal-magnetic "nerve center" includes:

Time-delay controlled by the load bimetal (12) for overload protection . . . ***overload bends free end of bimetal to right disengaging trigger (17) from armature (18) causing contact arm (19) to open.***

Second bimetal (13) of the "force balance" type, providing enclosure — ***ambient — compensation . . . as load bimetal (12) bends to right with rising ambient temperature, compensating bimetal (13) bends left, removing pressure from (12).***

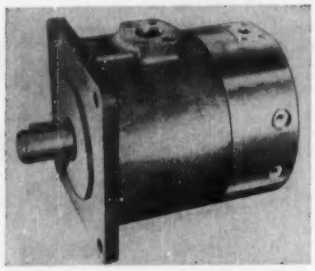
Magnet (20) reacts instantly by releasing trigger (17) at about 1000% rating to limit fault current damage.

The load bimetal and the compensating bimetal are made of dependable Chace Thermostatic Bimetal. This dependability is born of two most important factors: 1. Uniformity that comes from the manufacture of precision bimetal, ***always made to specifications.*** 2. Experience. Chace has specialized in one product—***and one product only***—for more than a third of a century. Manufacturers' valuable names are safe on the outside with Chace Thermostatic Bimetal on the inside of their products.

SEND NOW FOR OUR NEW "INFORMATION BOOKLET!" It contains many well illustrated pages of general information and examples of successful applications of bimetal. 36 types of Chace Thermostatic Bimetal are available in coils, strips and completely fabricated elements of your design.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.



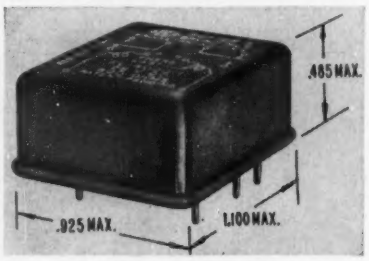
excellent suction characteristics. **Dynex Inc.**, 777 Dynex Drive, Pewaukee, Wis.

Circle 798 on Page 19

Latching Relay

lies parallel to surface of printed-circuit board

Dual-coil, microminiature latching relay has its smallest dimension perpendicular to the plane of its mounting surface. Designated Type FL, relay lies flat on a printed-circuit board, its maximum height being 0.485 in. Small height allows for closer stacking of circuit boards than has been possible. Relay is usually used without brackets or studs, simplifying installations. It requires an area of only 1.100 x 0.925 in. maximum on the circuit board. Relay withstands 100 g shock, 400 g linear acceleration, and vibration of 0.195 in. excursion from 10 to 55 cps and 30 g from 55 to



2500 cps with no contact openings in either armature position. **Potter & Brumfield Inc.**, Princeton, Ind.

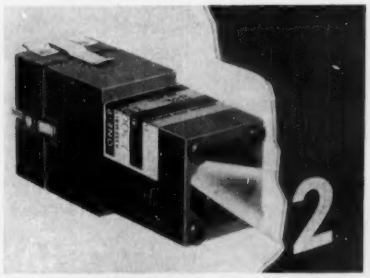
Circle 799 on Page 19

Digital Readout

miniature unit is subpanel mounted

Series 120000 subpanel mounted, miniaturized digital readout, mounted 13/16 in. behind a lucite viewing screen, rear-projects digit onto

viewing screen. Digits are visible from any angle of viewing. Unit is designed for use with digital computers, control equipment, instruments, aircraft equipment, production and inventory controls, and other electronic or electrical test equipment. Size of the character displayed on the viewing screen is 5/8 in. The light source comes from subminiature lamps; voltage is from 6 to 28 v. Unit features modular construction with an aluminum case. Dimensions are 3 1/8 in. long, 1 in. wide, and 1-5/16 in. high. Unit



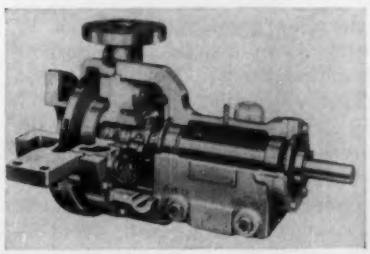
weighs 3 1/4 oz. **Industrial Electronic Engineers Inc.**, 5528 Vineland Ave., North Hollywood, Calif.

Circle 800 on Page 19

Centerline-Mount Pump

for medium-range service

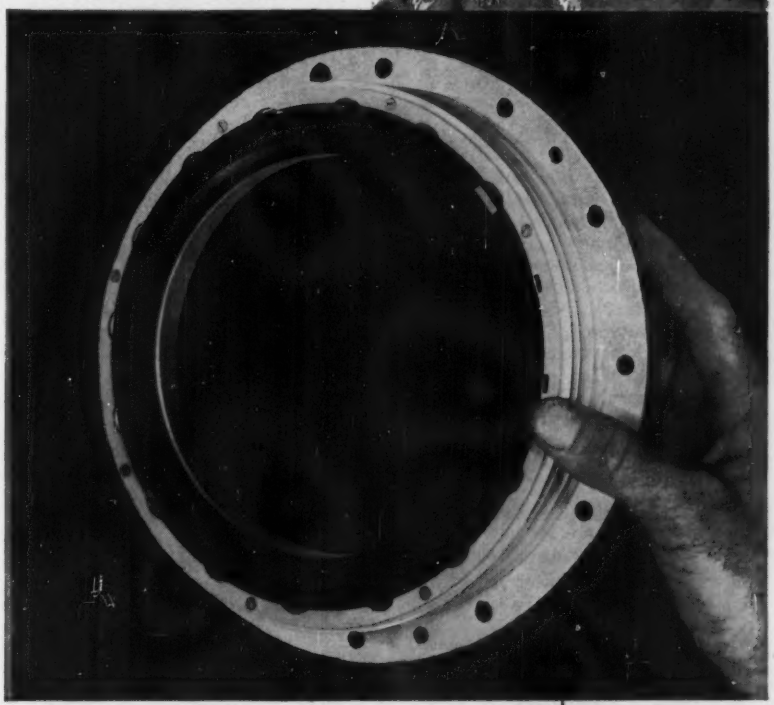
DMR medium-range, centerline-mount pump handles virtually all liquids used in refining and petrochemical manufacture. Unit features maximum parts interchangeability which allows a custom pump to be assembled from standard off-the-shelf components. Unit has a capacity of 900 gpm, heads to 450 ft, temperatures to 450 F, and working pressures to 300 psig. Basically a single-stage, horizontal, end-suction, top-discharge pump, unit is available in 1, 2, and 3-in. discharge sizes on an 8 1/2-in. frame, and 1, 2, 3, and 4-in. on a 10 1/2-in. frame.



Now...Borg-Warner Mechanical Seals for Airborne Applications

Developed especially to meet the reliability requirements of airborne components, this new Borg-Warner Mechanical Seal combines compact size with lightweight metallurgy. Entirely new—yet this same basic design has been proved in almost every type of industrial and military shaft sealing job.

Borg-Warner Mechanical Seals are used daily under high pressures, for high or ultra-low temperatures, to seal toxic, corrosive and volatile liquids, and even for radioactive fluids. *Whatever your needs for sealing a rotating shaft, a B-W Mechanical Seal can answer it.*



Typical operating conditions — rocket engine fuel pump at 7450 rpm and 250°F.

Borg-Warner®

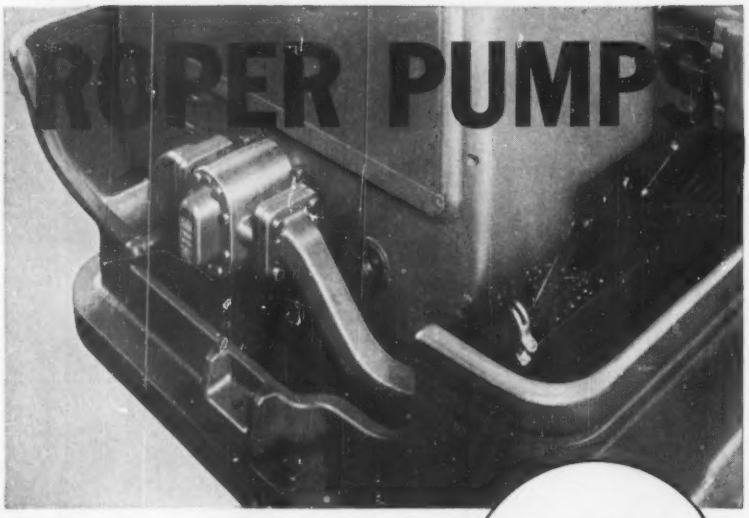
B-W Mechanical Seals

DIVISION OF BORG-WARNER CORPORATION

P.O. Box 2017, Terminal Annex, Los Angeles 54, California

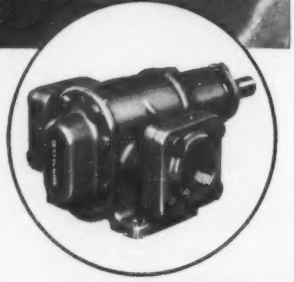
SEE OUR FILE IN SWEETS DESIGN CATALOG—SECTION 8e

Circle 568 on Page 19



SERIES K

adapted to the demands of a wide range of jobs



¾-50 GPM • PRESSURES TO 150 PSI • SPEEDS TO 1740 RPM

Typical of the great adaptability of the compact Roper Series K rotary pump is its service as a coolant pump in supplying soluble and cutting oils to this automatic screw machine. The requirement for instant priming in this machine requires a positive displacement pump. The rugged Series K meets the specifications of many original equipment manufacturers who require dependable, quiet, efficient transfer of clean liquids in hydraulic service, fuel supply duty for large oil burners, or diesel fuel oil transfer. Special fittings for transfer of corrosive liquids and special mountings to meet installation requirements can be supplied. Series K models can be direct connected, chain-, belt-, or gear-driven. Precision construction and thorough individual pre-testing insure its durability of performance. Specify Roper for rugged dependability.

Features behind Series K versatility

● Simplified design . . . only two moving parts ● Smooth flow . . . quiet operation ● Interchangeable mounting brackets . . . easy to install ● Precision-built . . . requires little operating power ● Self-priming . . . high suction lift . . . correct hydraulic principle ● Built-in relief valve . . . adjustable or pre-set.

For information about your specific pump needs, contact your nearest Roper dealer

Send for "How to Solve Pumping Problems" booklet

ROPER
HYDRAULICS, INC.

Dependable pumps since 1857
COMMERCE, GEORGIA

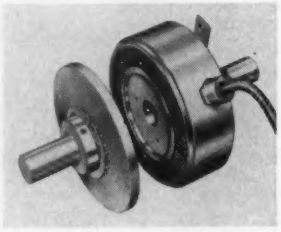
Bearing housing, shaft, and back plate are designated as a frame. Frame includes all parts except the volute, impeller, and wear rings. Virtually any machinable metal can be used in construction of pump part components. **Hydrodynamics Div., Peerless Pump Co., Food Machinery & Chemical Corp.,** 301 West Avenue 26, Los Angeles 31, Calif.

Circle 801 on Page 19

Stationary Magnet Clutch

has torque rating of 45 lb-ft

New clutch, designated 5.5 SMR, has a stationary magnet, ball-bearing mounted, for ease in assembly and alignment. Coils can be wound for voltages to 115 dc maximum, and insulated with Class A through Class H insulation. Torque is transmitted through a splined armature



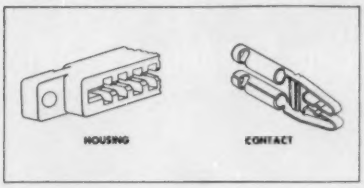
to the driven hub. Torque rating is 45 lb-ft, and can be converted to a magnetically set brake by securing rotor to magnet body. Clutch is available in split and through-shaft arrangements. Unit is also available in a clutch-brake combination. **Stearns Electric Corp.,** 120 N. Broadway, Milwaukee, Wis.

Circle 802 on Page 19

Printed-Circuit Connector

22-contact unit has taper-pin receptacles

Available for printed-circuit-card applications in which frequent jumpering is necessary, or in which numerous circuitry changes must be made, one-piece edge connector accommodates easy-to-insert, easy-to-remove taper pins. Connector, called Taper-in, mounts all 0.070 to 0.055-in. printed-circuit cards. Receptacles receive Series 53 taper-pin line, including both preinsulated and formed types. Connector has 22 contact positions, with contacts



commoned for multiple-wire use. Contacts are phosphor bronze, gold over nickel. Taper-pin receptacles are lettered and numbered to insure proper mating. **AMP Inc.**, Eisenhower Blvd., Harrisburg, Pa.

Circle 803 on Page 19

Aluminum-Oxide Ceramic

has maximum working temperature of 3200 F

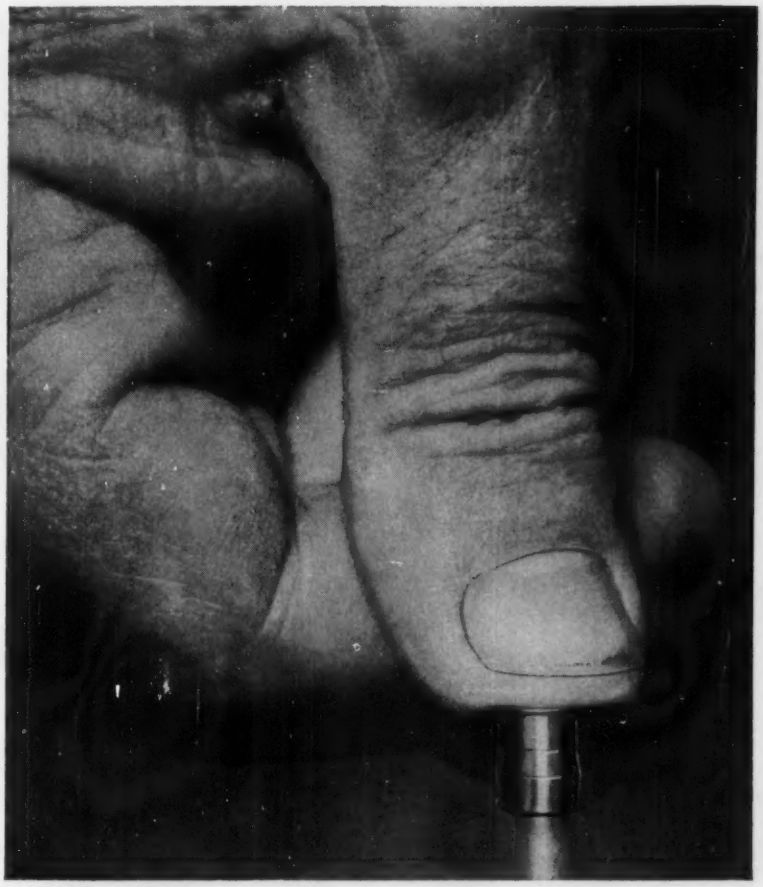
Vacuum-tight, high-strength, 99.5 per cent aluminum oxide ceramic, Type AD-995, is exceptionally strong at high temperatures, maintaining a flexural strength of 28,900 psi at 2000 F and 15,300 psi at 2500 F. Maximum working temperature is 3200 F when properly supported. Material is extremely resistant to abrasion and has a high resistance to corrosion, even at elevated temperatures. Ceramic has a wide range of industrial applications, and can be manufactured to extremely close tolerances. **Coors Porcelain Co.**, 600 Ninth St., Golden, Colo.

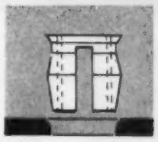
Circle 804 on Page 19

Digital Counter

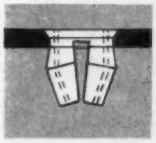
has counting rate to 150,000 counts per sec

Miniature, fast-counting, solid-state ring counter has a counting rate to 150,000 counts per sec. It will not miss a count, regardless of frequency, forward, backward, or intermittent switching. Counter is insensitive to conducted line noise, radiated noise, line voltage varia-

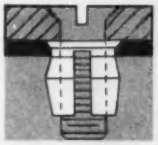




Into a countersunk hole, punched or drilled, of proper size.



Merely press a T Series BANC-LOK. Sharp edge of slot anchors itself to prevent turning.



Complete assembly with final locking action by inserting screw – the slotted end expands making the assembly vibration proof. Banc-Lok threads are reusable indefinitely without stripping.

Patented & Patents Pending

DO JUST THIS...

with a BANC-LOK INSERT

And You Have a Self-Locking Tapped Hole for Flush Fastening – No Costly Tapping – No Special Tools

BANC-LOK, the one-piece, self-locking insert, with reusable threads, eliminates costly tapping operations — is so quick and easy to apply that it slashes assembly costs. The T series Banc-Lok tapped hole is designed for any sheet metal fastening where non-strippable, reusable threads, with sure locking action are required. It is ideal for such applications as assembling electronic chassis, fastening hardware to metal doors and windows, locking adjusting screws and mounting instruments.

Banc-Lok tapped holes are available in a variety of designs (flat head, step type and spacers) and in a wide range of grip lengths to accommodate varying material thicknesses. For full details on sizes, types and application, send for the new Banc-Lok catalog, write:

BOOTS CORPORATION
312 NEWTOWN TURNPIKE • NORWALK, CONN.
Victor 7-2727 • TWX NWLK 95-U

BOOTS-WESTERN
432 NORTH LAKE AVE., • PASADENA, CALIF.
MU 1-6679 • TWX PASA CAL 7255-U

Circle 570 on Page 19

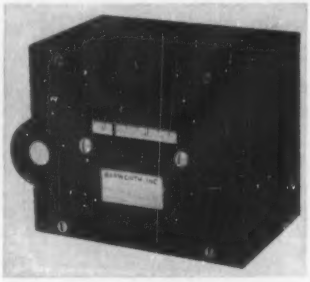
tions, pulse rise time, pulse width, and pulse magnitude. Standard model provides one output pulse for each count of ten input pulses. Counter operates within a temperature range of −55 to +125 C. **Tempo Instrument Inc.**, P. O. Box 338, Hicksville, L. I., N. Y.

Circle 805 on Page 19

Metering Valve

for panel mounting has direct-reading scale

No. 278 metering valve is suitable for use with liquids and gases at pressures to 1000 psi or vacuum service. It is available in orifice sizes from 1/16 to 1/4 in. diam. Suited for panel mounting, valve has a direct-reading scale. Control knob positions the valve and at the same time moves the pointer to relative position on the scale. Valve can be positioned throughout complete range while having a precise indication of position at all times. Valve stroke and scale lengths are relatively long. Unit is furnished in any suitable material to meet the particular application. Inlet and outlet ports are available in 1/8, 1/4, and 3/8-in. female pipe sizes. **Barworth Inc.**, 681 Morris Turnpike, Springfield, N. J.



Circle 806 on Page 19

Nameplate, Emblem Stock

of Mylar has adhesive with low initial tack

Decalar 956 is a decal material which combines the toughness and attractiveness of Mylar with new adhesive. The 3-mil metallized Mylar is available in chrome and gold which can be die-cut and silk-screened with standard screen processing inks or enamels. Adhesive has a low initial tack, building up to

WIPE OUT

Maintenance Costs!

Specify THOMAS FLEXIBLE COUPLINGS

Troublesome maintenance and lubricating problems are eliminated when you specify Thomas "All-Metal" Flexible Couplings to protect your equipment and extend the life of your machines.

Like a thief in the night an inadequate coupling causes wear and damage to your machines — resulting in high maintenance costs and costly shut-downs.

UNDER LOAD and MISALIGNMENT only THOMAS FLEXIBLE COUPLINGS offer all these advantages:

- Torsional Rigidity
- Free End Float
- Smooth Continuous Drive with Constant Rotational Velocity
- Visual Inspection While in Operation
- Original Balance for Life
- Unaffected by High or Low Temperatures

NO MAINTENANCE
NO LUBRICATION
NO WEARING PARTS
NO BACKLASH

Write for Our New Engineering Catalog 60

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA, U.S.A.

Circle 571 on Page 19

new source for Fine Seamless Tubing in NICHROME* V

80% Ni., 20% Cr. ALLOY

designed primarily for

- good electrical resistance
- temperatures to 2100°F
- good corrosion resistance

TYPICAL APPLICATIONS:

- resistance heating elements
- thermocouple protection tubes
- instrument components

AVAILABLE IN:

Sizes: from .010" O.D. to .375" O.D.

Wall thicknesses: from .042" to .001" (.0005" on special order).

Vacuum melted materials can be supplied where high ductility is required for fabrication.

FAST DELIVERY:

Normally 4 to 5 weeks from receipt of order.

WRITE FOR INFORMATION

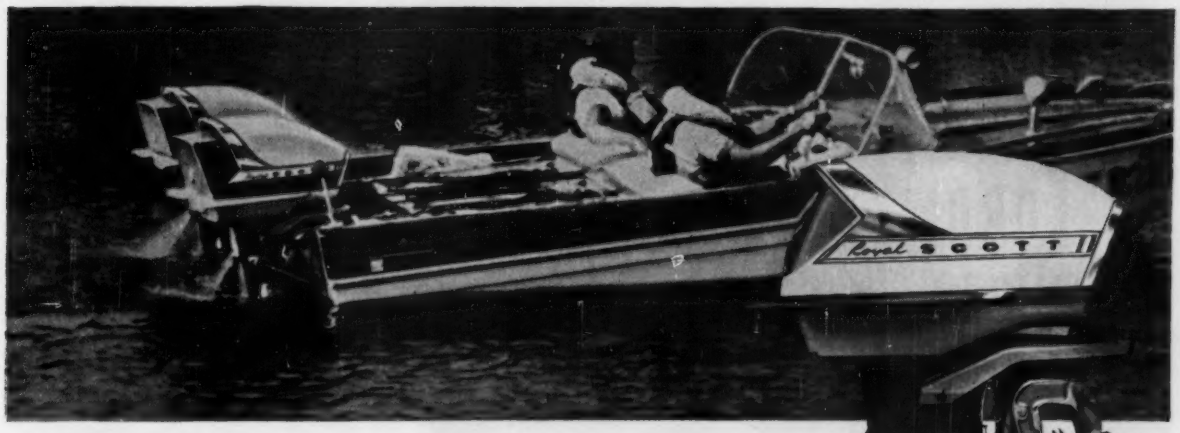
on your requirements in tubing or tubular parts "fabricated at the mill," made from this alloy . . . latest addition to the Uniform line which includes many alloys of aluminum, copper, nickel, steel and the precious metals.

*Reg. T.M. Driver-Harris Co.

UNIFORM TUBES, INC. COLLEGEVILLE 2, PA.
HUxley 9-7276 TWX-CGVL 1044

Circle 572 on Page 19

SCOTT OUTBOARDS *"Race-Horse Spirit . . . Work-Horse Power"*



Performance assured with VICTOR sealing

Scott motor owners know the satisfaction of superior outboard power—rocket getaway . . . smooth idling . . . sustained high-speed cruising —with fuel-saving economy!

It was Scott power that set the 1960 outboard endurance run down and up the Mississippi—4153 miles—in 165 hrs., 15 min. (Photo above.)

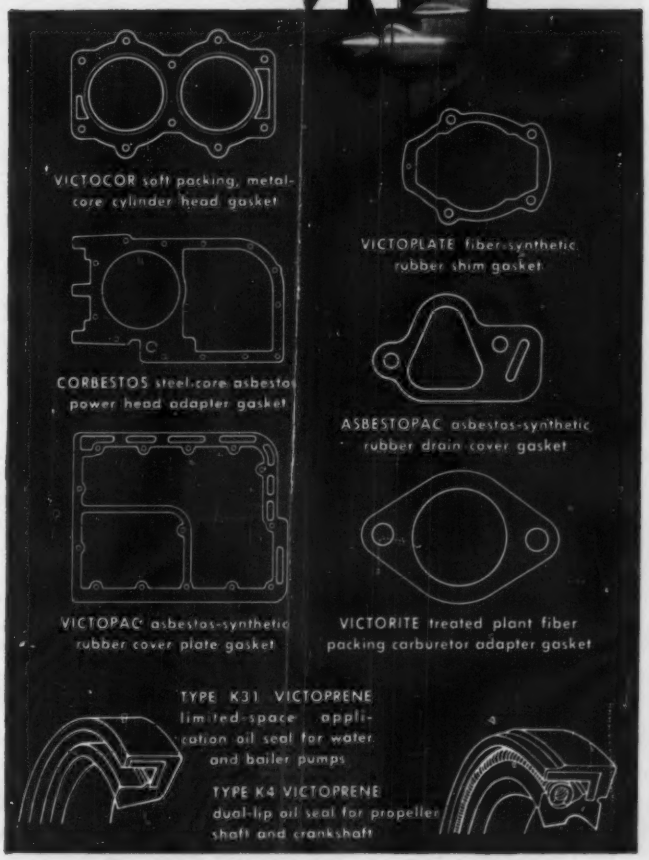
Sealing specifications play no small part of Scott motor dependability. For maximum power output . . . efficient carburetion and cooling . . . tight lubricant retention and water exclusion . . . heavy emphasis is placed on high-quality gaskets and oil seals.

Engineered Sealing—a Victor Specialty

For marine power units as for all types of engines, machinery and appliances, Victor sealing assures dependable, economical sealing. In standard gasket and oil seal designs, Victor's complete lines provide the widest selection. For nonstandard needs, 50 years' experience in designing and manufacturing to specification is at your service.

Write for New Catalogs

Comprehensive engineering catalogs for sealing specifiers are available through your Victor Field Engineer, or by letter request. Please state whether interested in gaskets or oil seals—or both. Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90. Canadian Plant: St. Thomas, Ont.

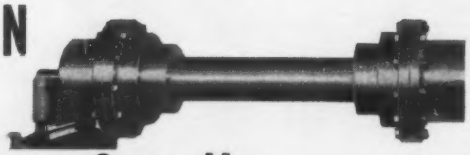

VICTOCOR soft packing, metal-core cylinder head gasket
VICTOPLATE fiber-synthetic rubber shim gasket
CORBESTOS steel-core asbestos power head adapter gasket
ASBESTOPAC asbestos-synthetic rubber drain cover gasket
VICTOPAC asbestos-synthetic rubber cover plate gasket
VICTORITE treated plant fiber packing carburetor adapter gasket
TYPE K31 VICTOPRENE limited-space application oil seal for water and bailer pumps
TYPE K4 VICTOPRENE dual-lip oil seal for propeller shaft and crankshaft

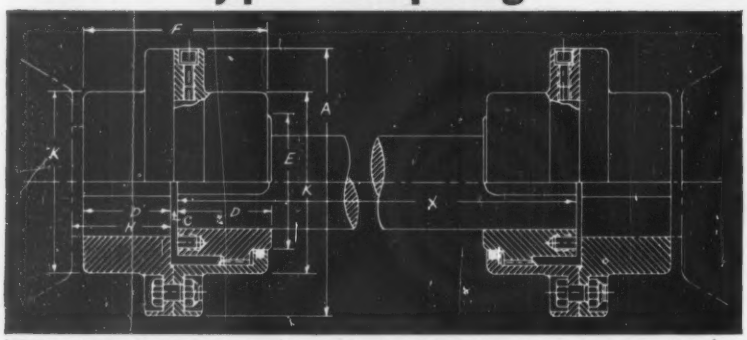
VICTOR *Sealing Products Exclusively*

GASKETS • OIL SEALS • PACKINGS • MECHANICAL SEALS

design facts....on

WALDRON Floating Shaft Type Coupling





Size	Max. Over Bore Flex. Half	Max. Over Bore Rigid Half	H.P. Per 100 R.P.M.	A	C	D	D¹	E	F	H	K	X	Ship. Wt.* in Lbs.	Total Oil Req'd In Pts.	Size
				Dimensions in Inches											
1½A	1⅛	1⅛	3½	4⅝	⅛	1½	1 11/32	2	2⅜	1½	2 11/16		22	1/10	1½A
2A	2⅛	2⅛	12	6	⅛	2¼	1 25/32	2⅞	4	2¼	3 3/4		42	⅛	2A
2½A	2⅝	3	26	7	⅛	2¼	2 5/32	3⅜	4½	2¼	4 7/32		70	⅛	2½A
3A	3⅜	3⅜	50	8⅛	⅜	3 1/32	2 27/32	4¼	5⅛	3¼	5¾		120	¼	3A
3½A	3⅜	4¼	86	9¾	⅜	3 13/32	3 13/32	5	7	3¾	6¾		160	⅓	3½A
4A	4⅛	4⅞	130	11	⅛	4⅝	3 15/16	5⅝	8 1/16	4¼	7 11/16		215	⅜	4A
4½A	4⅛	5⅝	210	12½	⅛	4¾	4 13/32	6½	9 5/16	4¾	8 21/32		350	1	4½A
5A	5⅛	6⅛	300	13⅝	⅜	5⅛	5	7⅛	10⅛	5¼	10⅛		460	1½	5A
5½A	6	7⅛	410	15⅝	⅜	6⅛	5¼	8	11⅞	6	11⅞		650	2	5½A
6A	6⅞	8	550	16⅝	⅜	6⅞	6⅛	8⅝	13⅜	6⅝	12¾		820	2½	6A

*Weight of Floating Shaft not included.

The floating shaft arrangement meets the problems of remote drives and excessive misalignments. This arrangement consists of two rigid female hubs on the driving and driven machines with a male half of a standard coupling on each end of the floating shaft, that separates the connected machines. The length of the floating shaft is limited by the critical speed, since this arrangement requires no intermediate bearings. The hub arrangement can be reversed, that is, the rigid hubs can be installed on the floating shaft and the flexible halves on the driving and driven machines. This arrangement is optional, except that it is better practice to have the rigid hubs on the driving and driven machines in the event that it is necessary to run the machines independently.
Write for Catalog.

WALDRON Couplings

WALDRON-HARTIG DIVISION
MIDLAND-ROSS CORPORATION
BOX 791, NEW BRUNSWICK, N. J.

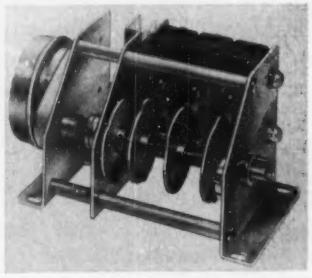
Circle 574 on Page 19

an adhesion of over 90 oz per in. within 24 hr. Adhesive and backing are impervious to oil, grease, gasoline, solvents, detergents, water, acids, and alkaline solutions. Material adheres firmly to any metal, wood, glass, leather, or plastic surface, painted or unpainted. Initial low tack allows easy release from interliner and permits repositioning of the decal if necessary without loss of ultimate bond strength. Over-all thickness of almost 5 mils makes the material suitable for use on surfaces that are not perfectly smooth. Surface imperfections will not show through or puncture the decal. **Permacel**, New Brunswick, N. J.

Circle 807 on Page 19

Cam Timer

features an external clutch



Series 650 multiswitch cam timer has an external clutch which permits instant automatic reset, regardless of time cycle. Any cycle from 1 sec to 60 hr can be specified. From two to five load switches are available; unit is also available with adjustable or preset cut cams. **Industrial Timer Corp.**, 1407 McCarter Highway, Newark 4, N. J.

Circle 808 on Page 19

Knobs

are zinc or aluminum

Series MS 91525 knobs, of zinc or aluminum, are painted olive drab per Spec 72-53 or navy gray per Spec P513, both with phosphorescent paint per Spec TT-P54 in index groove. Knobs are used on AN/GRC, AN/PRC, AN/TRC, and AN/VRC equipment. They are available from stock. **Vemaline Products Co.**, Franklin Lakes, N. J.

Circle 809 on Page 19

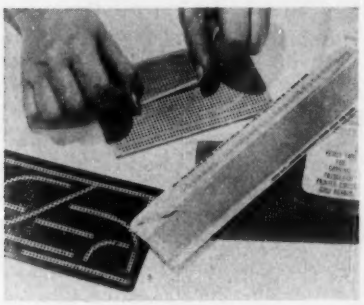
ENGINEERING DEPARTMENT

EQUIPMENT

Tape Kits

for Fotoceram grid boards

Convenient kits of plastic strips and dots are available for laying down circuit patterns on copper-clad Fotoceram printed-circuit grid boards. Strips and dots withstand acid, so that when grid boards are dipped in copper-etching solution, the only copper that remains consists of the desired circuit layout. Plastic adheres on contact, yet lifts easily after etching or if corrections are desired before etching. Grid boards enable designers to make prototype printed circuits in 15 min. They consist of copper-covered Fotoceram glass-ceramic with 0.052-in. holes on a 1/10-in. grid. Tape kits contain



ten 9 x ⅛-in. strips and forty 3/16-in. dots. **Electronic Components Dept., Corning Glass Works,** Corning, N. Y.

Circle 810 on Page 19

Strain-Gage Transducer

miniature unit features high frequency response

Model P318 microminiature, flush-diaphragm, absolute-pressure transducer features high frequency response. Weighing only 0.5 gram, unit measures 0.59 in. diam by 0.05 in. thick. Incorporating unbonded complete strain-gage bridge, unit has wide application in missile, air-

These RMC thermometers have just been submerged in water for the first of a severe series of tests to make sure of perfect hermetic sealing.

Moisture will never bother your RMC dial thermometer

The RMC hermetic sealing process makes absolutely certain that humid air will not be sealed in the instrument and locks all moisture out permanently. Each thermometer then goes through a series of severe tests. Only those with perfect sealing are accepted for delivery. When you order from RMC you get the *only* industrial thermometer that can *never* be affected by internal dial fogging or bimetal freeze-up.

"Bimetal Freeze-up" More Serious Than Dial Fogging

The first sign of moisture in a dial thermometer usually shows up as condensation inside the dial glass. You are probably familiar with this dial fogging problem which causes difficult reading and the eventual corrosion of the bimetallic element. You may not, however, be familiar with another and actually more serious moisture problem—bimetal "freeze-up."

If moisture is sealed in, or enters a thermometer dial it will find its way to the bimetal element. Then at extreme low temperatures this moisture freezes on the element and bearing surfaces, and the bimetal element will not function should the temperature go lower. Therefore, the operator of the equipment would never know that the temperature had gone below the last indication when the element became frozen.

Here's what makes such a condition hard to spot. The thermometer would operate properly again after a temperature rise of perhaps 20°, and would continue accurate indication even though the fluid dropped again to an even lower temperature than before. However, after it remained at the new low for a few hours, it would again freeze up. Then, as before, any further drop in temperature would not be indicated.

Only a dry-air hermetic seal, as used by RMC, can prevent both dial fogging and bimetal freeze-up. RMC even goes a step further by providing for recalibration at any time without breaking the air-tight seal. An external dial reset screw—exclusive with RMC—permits recalibration without opening the instrument in any way.

Write, wire or phone for general catalog. If yours is a special application, tell us your requirements—RMC engineers will work with you in solving it. Rochester Manufacturing Co., 229 Rockwood St., Rochester 10, N. Y. (Telephone: BRowning 1-2020).

RMC

ROCHESTER MANUFACTURING CO., INC.
229 ROCKWOOD STREET • ROCHESTER 10, N.Y.

LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

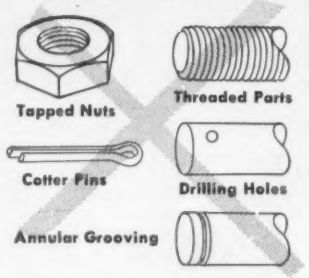
REPRESENTATIVES IN ALL PRINCIPAL CITIES

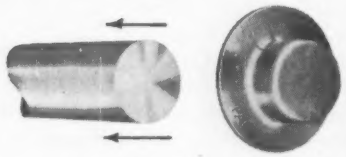
Circle 575 on Page 19

Investigate this wide choice of PUSHNUT® FASTENERS to speed up and cut costs of Assembly

- **SIMPLY PUSH ON** plain rods, axles, studs or pins.
- Easy, fast assembly with manual tools or high speed air hammers.
- Tight, vibration-proof grip.

Eliminate these costlier parts and operations





WASHER CAP TYPE

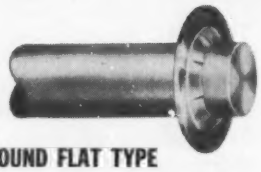
Style PW. Covers rod ends with smooth, rugged cap. Made of one-piece, heavy gauge spring steel with powerful gripping action. Always align perfectly. Various designs and finishes in sizes for 3/16", 1/4", 5/16", 3/8", 7/16" and 1/2" dia. unthreaded rod, wire and studs.

Style PC

Style PK

ACORN TYPE

Pleasing, decorative appearance and strong spring grip for fastening or covering ends of rods, studs, pins, etc. Closed and open end styles. Sizes from .120" to .312" dia.



ROUND FLAT TYPE

Style PS. Low-cost, space-saving spring steel retainers push on plain rod or axle, providing strong, firm retention of parts, seated or unseated. eliminate notching, grooving, drilling and cotter pins. Sizes for 1/16", 3/32", 1/8", 3/16", 1/4", 5/16", 3/8" and 1/2" dia. rod.

Style PV. Light duty retainer with flexible spring gripping teeth for easy assembly with fingers. For rod dia. 1/4", 5/16", 3/8" and 7/16".

ARCHED RECTANGULAR TYPE

Style PH. Push on unthreaded studs to assure tight, vibration-proof assembly of ornaments, medallions, nameplates and other parts. Grip tight on hard chrome studs. Sizes for 1/16", 5/64", 3/32", 1/8" and 5/32" dia. studs.

Write for Free Samples and Data, stating type, size and application.

PALNUT®

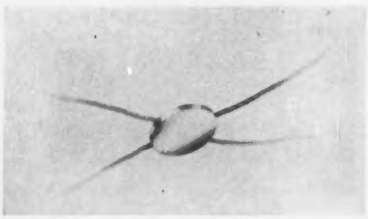
THE PALNUT COMPANY

DIVISION OF UNITED-CARR FASTENER CORPORATION

75 Glen Road, Mountainside, N. J.

Canada: P. L. Robertson Mfg. Co., Ltd., Milton, Ont.

LOCK NUTS and FASTENERS



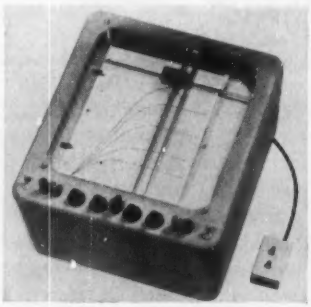
borne, and wind-tunnel installations where small size and light weight are critical. Ranges are 0-10 to 0-100 psi, available in absolute, gage, or differential. Excitation is 15 v, and output is 5 mv, full scale open circuit. Combined error due to nonlinearity and hysteresis is less than ±1 per cent of full scale. Ambient temperature limits are −65 to +150 F. **Statham Instruments Inc.**, 12401 W. Olympic Blvd., Los Angeles 64, Calif.

Circle 811 on Page 19

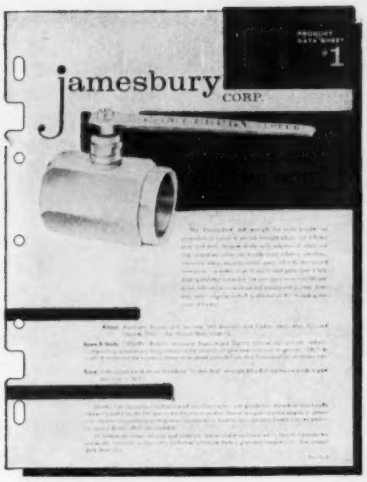
X-Y Recorder

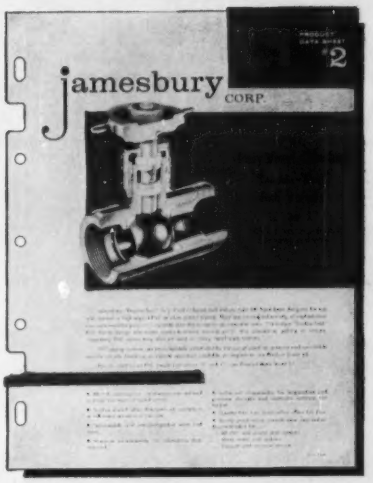
incorporates electric pen-lift mechanism

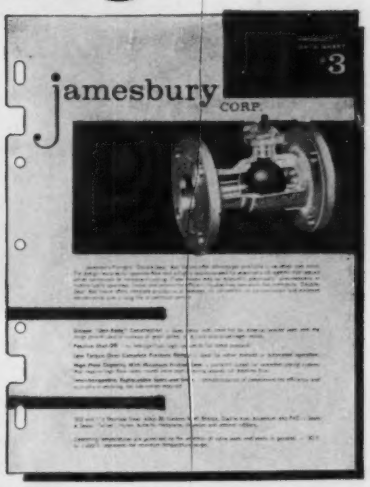
Model HR-93 X-Y recorder has a simple, rugged, electric pen-life mechanism allowing point plotting, family-curve tracing, and rapid, non-recording pen indexing. Pen lifter can be operated with the hand-held manual-control box or can be tied into the test circuitry for automatic operation. Load-operated switch automatically picks up the pen and indexes it away from the chart area so that the graph paper can be loaded easily with no trace appearing on the chart. After loading, pen is held up so that no trace appears when indexing back to the original position. Flat-bed construction, coupled with use of standard 8½ x 11-in. graph paper, makes unit universally simple in operation and construction. Each axis con-



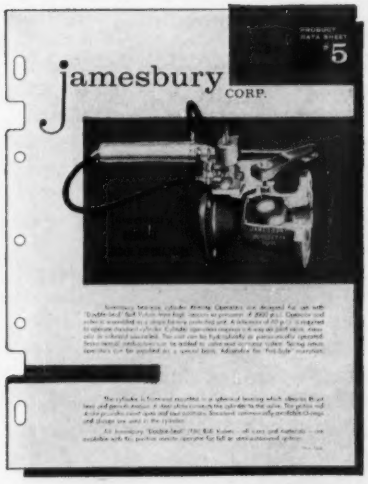
Yours For The Asking!

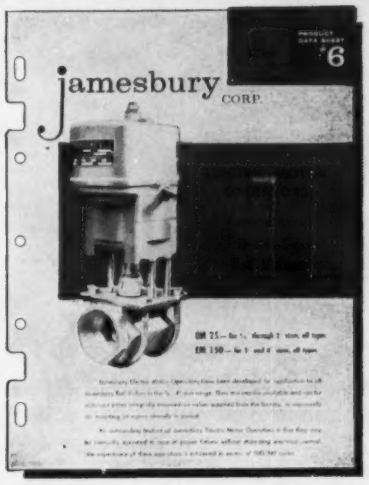


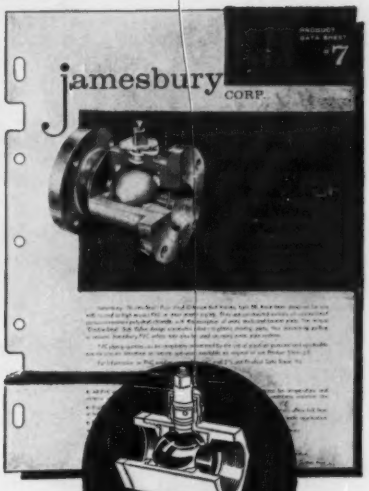


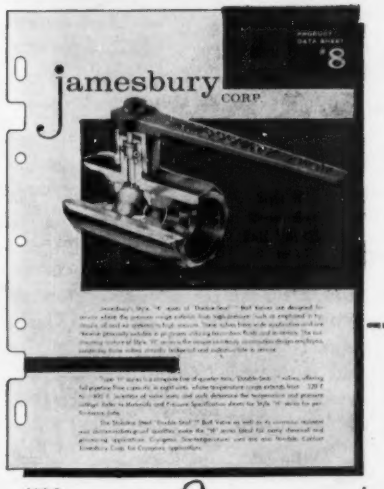


FACTUAL DATA









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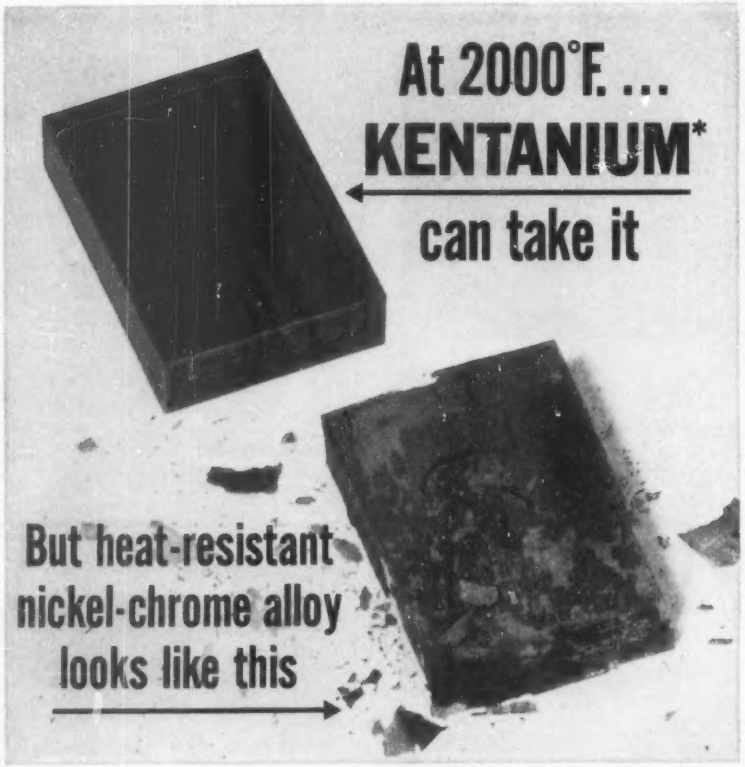

A square of Kentanium K161B (top) and one of heat-resistant 35 chrome —15 nickel alloy (bottom) show the effect of 120 hours' exposure to 2000°F. in an unsealed muffle furnace.

If you need a design material that can take temperatures up to 2200°F. under continuous operation, or higher temperatures for short duration . . . there's a good chance Kentanium can solve the problem.

In addition to its outstanding oxidation resistant qualities, Kentanium has other problem-solving properties. For example . . . the highest stiffness-to-weight ratio of any material, as Kentanium is only ⅔ the weight of steel . . . and has a YME up to 60-million psi. Kentanium also has high resistance to abrasion, corrosion, and great strength at high temperatures.

For temperature sensing elements, rotary seal rings, hot rod mill guide inserts, nuclear reactor components, balls for pump check valves, spinning tools for hot metals . . . and maybe for *your* product . . . Kentanium offers many advantages.

For more information, send for these two booklets: B-444-A, "Kentanium," and B-666, "Proven Uses of Kennametal and Kentanium." KENNAMETAL INC., Latrobe, Pennsylvania. 33516

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tains its own power supply, attenuator, and zero control, and is independent both mechanically and electrically of the other. Accuracy is ½ per cent with 7½ ips pen speed on both axes. **Houston Instrument Corp.**, P. O. Box 22234, Houston 23, Tex.

Circle 812 on Page 19

Temperature Chamber

for temperatures from −150 to +300 F

Designed for moderate production and environmental testing, continuous operation or intermittent use, new 2-cu-ft unit meets requirements for versatility, reliability, and economy. Model A-120-2-HC affords a temperature range from −150 to

+300 F, ±2 per cent with indicating controller. Chamber measures 24 x 12 x 13½ in. Unit incorporates fin coil and blower, two 2-in. ports, lid with multipane frost-free window, lifetime silent signal, and internal illumination. **Cincinnati Sub Zero Products**, 3932 Reading Rd., Cincinnati 29, Ohio.

Circle 813 on Page 19

Photocopier

has cartridge with premixed developer

Transamatic photocopier incorporates a no-mix cartridge containing completely premixed solution. Cartridge is snapped into place for use and snapped out when solution eventually is used up, eliminating all handling. Solution is automatically forced to flow into the tray when unit is turned on, and automatically returns to the cartridge as the machine is turned off. Copier reproduces any color, anything written, typed, printed, or drawn. Copies are on white paper,

Circle 578 on Page 19

or can also be made on a variety of colored papers. Unit requires only 11 seconds per copy, is all electric. **Transcopy Inc.**, 10 Paterson Ave., Newton, N. J.

Circle 814 on Page 19

Engineering Desk

has 43½ x 72-in. drawing surface

Multipurpose engineering desk provides a 43½ x 72 in. linoleum drawing surface with roll-holding brackets to simplify handling of large drawings. Unit converts instantly into an office desk and supplies two files to accommodate all filing requirements. Files can be used independently of the board if desired. Entire assembly consists of three basic parts—steel, linoleum-covered top; and two files. It can be assembled in minutes without tools, is simple to handle and easy to

move. **Drafting Products, Hamilton Mfg. Co.**, Dept. WH317, Two Rivers, Wis.

Circle 815 on Page 19

DC Power Supply

provides output voltages in three ranges

Low-cost DC power supply, Model P60-1, is available for use in research and development laboratories which do not require close regulation of extremely low ripple. Incorporating all solid-state components, the general-purpose power supply pro-

This New Lightweight Miniature Power Tool

- installs *Heli-Coil* Screw Thread Inserts, both Standard and Screw-Lock, in sizes 4-40 through 8-32.
- permits quick and easy size changes.
- is easy to use in restricted areas and miniaturized products.
- operates from remote motor with flexible shaft.
- is provided with automatic clutch and precision depth adjustment.
- speeds production and cuts costs.

Heli-Coil Stainless Steel Wire Screw Thread Inserts protect threads permanently against wear, corrosion, stripping, galling, and seizing.

Write for Bulletin 770A with complete information about this new *Heli-Coil* Power Tool.

HELI-COIL CORPORATION
512 Shelter Rock Lane, Danbury, Connecticut
In Canada: ARMSTRONG BEVERLEY ENGINEERING LTD.
6975 Jeanne Mance St., Montreal 15, Que.

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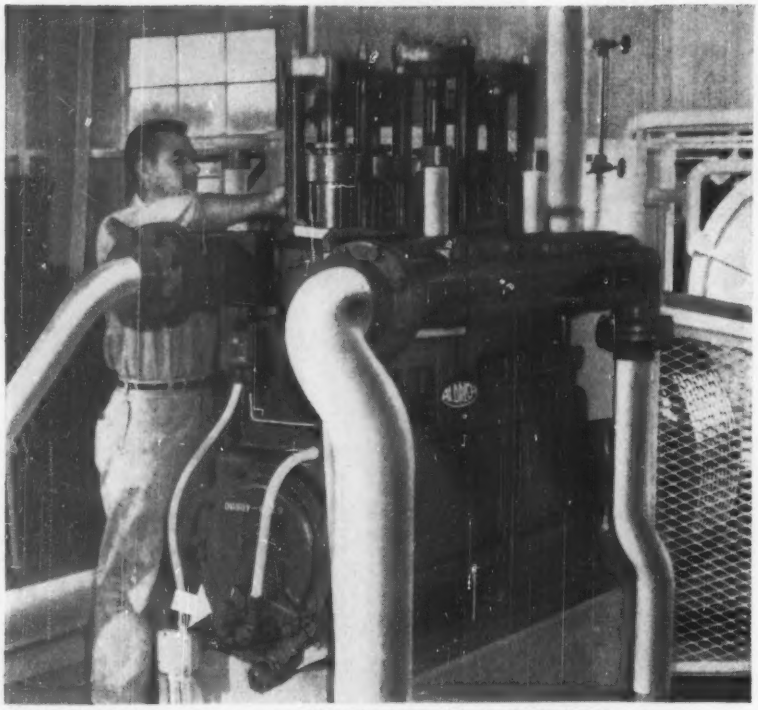
Circle 579 on Page 19

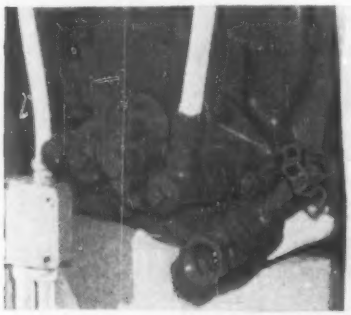


Aldrich Direct Flow Pumps are used throughout industry, for liquid transfer and in central hydraulic systems.

"Never had a 'lemon' yet in lube pumps bought from Brown & Sharpe!"

. . . Mr. S. G. Kooker, Chief Engineer, Aldrich Pump Company, Allentown, Pa.

"Nobody I know of makes a better small pump than Brown & Sharpe," says Mr. Kooker.



B&S Rotary Gear Pump (arrow, above) lubricates "power end" of Aldrich Pumps. Standard B&S Nos. 1, 2 or 4 models are used, with only slight modifications of shaft extensions or flanges.

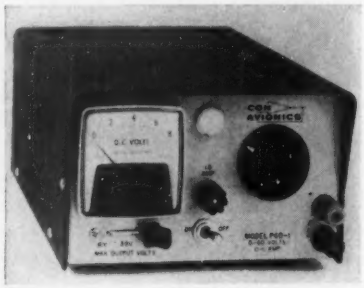
"Their quality is tops . . . they have a full range of sizes and models to meet our requirements. And we've never had a 'lemon' yet in lube pumps bought from Brown & Sharpe!

"We've been installing them for lubrication in our reciprocating pumps for 14 years . . . and their maintenance problems have been negligible in all that time."

To help assure trouble-free performance in *your* machines, specify Brown & Sharpe pumps. They're made right, priced right! For the comprehensive Catalog No. 36P, contact Hydraulics Division, Brown & Sharpe Mfg. Co., Providence 1, Rhode Island – or your nearest B&S engineer-representative.

Brown & Sharpe
PRECISION CENTER

Circle 580 on Page 19



vides continuously variable output voltages in three ranges—0 to 6, 0 to 30, and 0 to 60 v dc. Selection of output voltage range is made by a three-position toggle switch. Maximum output current is 1 amp in any of the voltage ranges. Input power required is 115 v, 60 cycle, single phase ac. Units measure $7\frac{1}{8}$ x $4\frac{1}{2}$ x $11\frac{1}{2}$ in., and are designed for bench-top use and easy stacking. **Consolidated Avionics Corp.**, 800 Shames Drive, Westbury, L. I., N. Y.

Circle 816 on Page 19

Strain-Gage Indicator

has eight calibrated sensitivity ranges

Accurate indication or recording of static and dynamic strain-gage measurements is achieved with Model 800 strain-gage indicator. Instrument provides features and adjustments to accommodate all commonly used gage factors, gage resistances, and transducer-bridge configurations. Eight calibrated sensitivity ranges cover all normal requirements. Maximum resolution is better than 1 mu-in. per in. Accuracy of panel meter indication is 1 per cent of scale. AC operation with regulated internal excitation source eliminates need for batteries. Electrical output is provided for op-

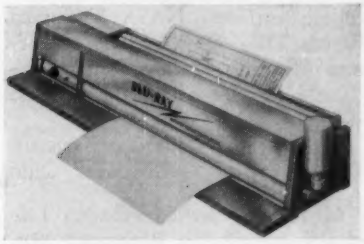
eration of standard potentiometer records, cathode ray, and recording oscillographs. **Daytronic Corp.**, 225 S. Jefferson St., Dayton 2, Ohio.

Circle 817 on Page 19

Dry Developer

is portable, rotary-type unit

Low-cost, continuous-action Blue-Ray unit for developing diazo papers and materials is a portable, rotary-type dry developer. It develops prints to 42 in. wide of any length, at variable speeds from 4 to 72 ipm. It provides faster print developing production than stack or tube-type developers, and eliminates filling ammonia cups. In addition to diazo papers, machine develops foils, se-



pias, and sensitized cloth. **Reproduction Engineering Corp.**, 613 Plains Rd., Essex, Conn.

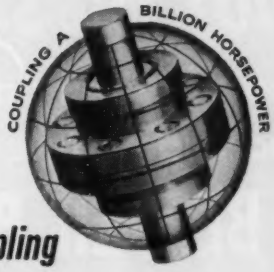
Circle 818 on Page 19

Erasable Sepia Intermediate

takes pencil, ink, and typewritten additions

No. 402 IZE erasable sepia intermediate permits making engineering and drawing correction and changes quickly and easily, without altering or damaging originals. A reverse-reading duplicate copy of the original is made on the new paper. It permits unwanted information to be erased, and correct details are added on reverse side in pencil, ink, or typewriter. Highly transparent base has excellent show-through. Unsensitized matte surface retains its tooth after repeated erasures. Plastic coating on both sides resists water and grease, protects sepia image, and cleans with a damp sponge. **Ozalid Div., General Aniline & Film Corp.**, Johnson City, N. Y.

Circle 819 on Page 19



More equipment manufacturers choose Fast's Couplings than any other gear-type coupling

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Every Fast's Coupling brings you superb engineering only the original gear-type coupling can deliver. Smooth-running units that are designed to outlast the machines they connect. Rapid service from experienced field engineers backed by outstanding stock facilities. Write today for full details on couplings to suit your needs to: KOPPERS COMPANY, INC., Fast's Coupling Dept., 412 Scott St., Baltimore 3, Maryland.

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Circle 581 on Page 19

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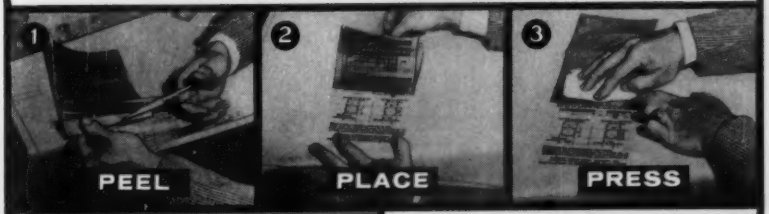

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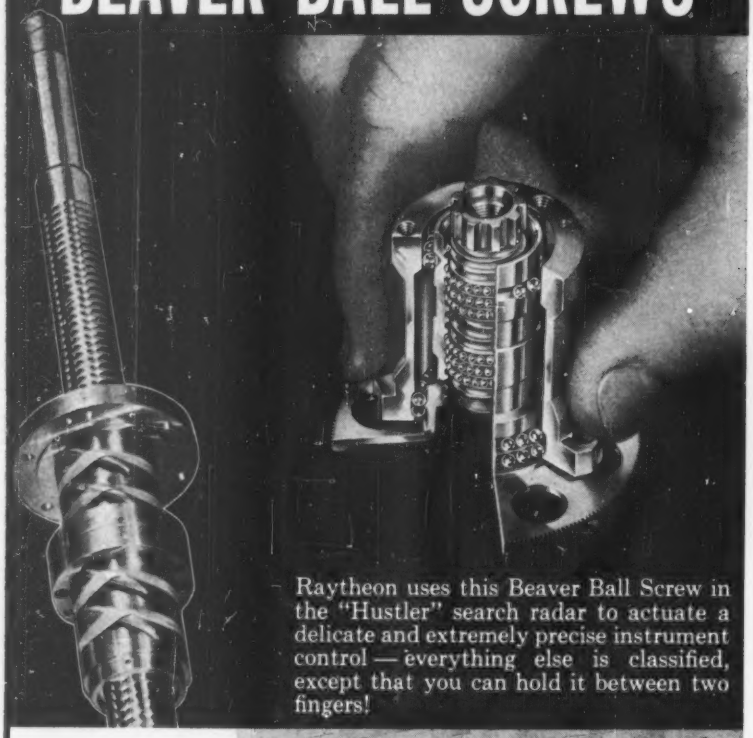
Circle 582 on Page 19

NOT THE SIZE OF THE JOB

but the demand for positioning accuracy determines the need for

BEAVER BALL SCREWS



Raytheon uses this Beaver Ball Screw in the "Hustler" search radar to actuate a delicate and extremely precise instrument control — everything else is classified, except that you can hold it between two fingers!

One of the largest ball screws ever built. This 40 foot Beaver Ball Screw positions the carriage of a giant steel mill roll lathe designed by the McIntosh-Hemphill Div. of E. W. Bliss. Chief advantages were minimized break-away friction and reduced power.

Our engineers will be glad to work with you in determining if ball screw actuation belongs in your product as opposed to hydraulics or pneumatics. Call on us.

Largest manufacturers of precision ball screws

Beaver Precision Products INC.

CLAWSON, MICH.

Professional Viewpoints

. . . oscillation life of bearings, sliding, rolling surfaces . . .

To the Editor:

My apologies to you and your readers for what have been so kindly called "inaccuracies" in my last two technical articles. Also, my thanks to you for making the corrections (below) available to your readers, and to Mr. A. B. Jones of New Britain, Conn. for calling these points to my attention.

May I also add a new reference containing very thorough test data and some discussion on sliding in rolling surfaces: NASA Technical Report TR R-60, "A Study of Factors Affecting Rolling-Contact Fatigue Life," by Thomas L. Carter, 1960.

—THOMAS BARISH
Cleveland, Ohio

Corrections for "Oscillation Life of Ball and Roller Bearings," MACHINE DESIGN, Sept. 1, 1960:

The second equation, page 114, should be

$$p_z = p_0(\cos\alpha)^{5/2}$$

This changes subsequent equations, page 114, to

$$p_e = p_0\left[\frac{2}{\pi}\int_0^{\pi/2}(\cos\alpha)^{9/2}\,d\alpha\right]^{1/3}$$

$$p_e = 0.709\,p_0$$

$$R_R = 0.709\left(\frac{nH}{8}\right)^{1/3}$$

$$= 0.35(nH)^{1/3} \qquad (1)$$

$$R_T = 0.56(nH)^{1/3} \qquad (2)$$

and on page 116, the last sentence in the first paragraph should read: For radial load, the second pair of stresses is smaller, in the ratio of $(\cos\theta)^{3/2}$ and the capacity is reduced by the ratio of

$$\left(\frac{1}{1+(\cos\theta)^{9/2}}\right)^{1/3}$$

Other equations affected on page 116 are:

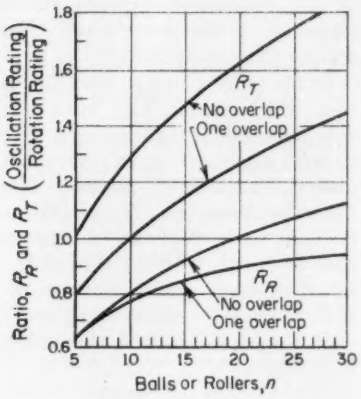
$$R_R = 0.35\left(\frac{nH}{1+(\cos\theta)^{9/2}}\right)^{1/3} \qquad (1a)$$

$$R_T = 0.44(nH)^{1/3} \quad (2a)$$

$$R_R = 0.35(nH)^{0.3} \quad (1b)$$

$$R_T = 0.58(nH)^{0.3} \quad (2b)$$

and Fig. 4 becomes



In the first paragraph under "Roller Bearings," the sentence should read: Life varies with $(1/P)^{10/3}$, not $(1/P)^3$.

Corrections for "How Sliding Affects Life of Rolling Surfaces," MACHINE DESIGN, Oct. 13, 1960:

Values under "Life varies with:" in Table 2, page 192, should be $1/S^9$ and $1/S^6$

The end of the first paragraph under "Subsurface Stresses," page 193, should read: 2. It shifts the location of this stress to about half the distance from the surface.[7]

. . . the salaried professional . . .

To the Editor:

In your guest editorial, "The Salaried Professional" (MACHINE DESIGN, Sept. 15, 1960), the term *professional engineer* is used but is not defined. Because this term is not defined, I and many other engineers feel the "trade" uses this term loosely.

A man with a sheepskin is clearly defined on his diploma as to the type of engineer he has the right to profess. When he is recognized politically in his area, he obtains the right to be listed as a "registered engineer," but I and many others feel that only that engineer who hangs up his shingle in a selected community to advertise his willingness to assume his full share of the business and *profession-*

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Two-Bearing Motor-Generator Set

Circle 584 on Page 19

Ball retainers of antifriction

RULON A*

add extra life and extra use to antifriction bearings

A well-known bearing manufacturer, after testing many metallic and non-metallic materials for use as ball retainers, standardized on Rulon A to insure far greater service life for their bearings. Dixon's "superTeflon" contributes many performance advantages in this application:

- Because of its low coefficient of friction, the Dixon-supplied retainers help keep frictional heat to a minimum, guarantee low starting torque, and smooth vibration-free performance.
- Due to its engineered reinforcing, Rulon A provides high resistance to wear and deformation under load . . . assuring precise spacing of balls.
- Because of high thermal and chemical adaptability of Rulon A, the manufacturer now can offer bearings for the widest variety of service conditions. Rulon A retains its mechanical properties over −450°F to +550°F temp. range . . . has practically universal chemical inertness.
- The Rulon A retainers serve a dual role, having the ability to run completely dry—or to greatly extend performance with the use of lubricants.

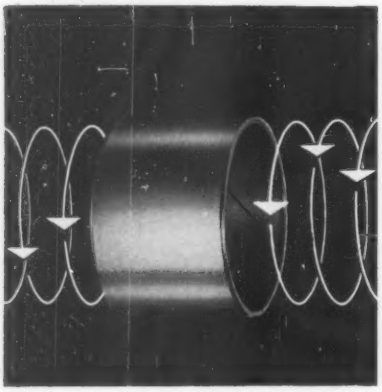
As in the development of these efficient ball retainers, Dixon's research and engineering groups are ready to assist design engineers in the successful and profitable application of Rulon to their products. Knowledge of standard or special reinforcing additives plus a broad experience in the manufacture of molded, extruded, or machined parts make Dixon the ideal source for sleeve bearings, bushings, thrust bearings, wear strips, cam followers, relay pushers, torque control bushings, and many other mechanical and electrical components.

*One of Dixon's many modifications of Du Pont TFE Teflon

Write for Engineering Data Sheets on **RULON**

DIXON Corporation, Bristol, R. I.

Dixon Suppliers of basic shapes and fabricated parts in Rulon and Teflon



Shafts run smoother and longer on RULON T-LINER BEARINGS

Dixon's T-Liner Sleeve Bearing . . . with antifriction "floating" Rulon insert (modified TFE Teflon*) . . . is designed for applications that require high wear resistance with no lubrication. Available from stock in 10 standard sizes for ¼" to 1¼" shafts. Bulletin 32-T gives full details on coefficient of friction (low!), chemical inertness (high!), and price (low!). Write **Dixon Corporation, Bristol, Rhode Island.** *Du Pont TM

Dixon

at life of that community, with all its attending risks, is a professional.

When a costly error has been made, who is responsible? The salaried engineer who made the error, or the professional engineer whose name is on the front door? Who accepts the responsibility?

In my office I have a neat legible sign which reads, "Our time and our responsibility are all we have to sell—don't ask us to give either away." The salaried engineer does not subscribe to this. The employee-engineer gets paid for a specific task of labor, whereas the professional engineer assumes the responsibility of the salaried engineer's work besides his share of community responsibility.

The professional engineer is to salaried engineers what a college professor is to a teacher. There may be but a little difference, but "Oh that little bit of difference."

—A. T. CASSIERE
Consulting Engineer
Fontana, Calif.

They Say . . .

"Research is the life blood of a large segment of industry today. Some of it fits into the definition of research as . . . *study and investigation to establish facts or principles.* The responsibilities for such research must be assumed by large and strong institutions, whether organized for profit or not, because true basic research cannot be hampered by any demand for profits, present or future. The costs are high, the results unpredictable, and there must be financial ability as well as determination at top levels to seek truth regardless of profit or products if such research is to truly succeed."
—E. H. PERKINS, *president, Brooks &Perkins Inc., Detroit, Mich.*

"Since, by the 1957 estimate, we are already devoting three out of every thousand people to engineering, it is hard to see how the society may afford much greater fractions in the engineering profession without becoming completely lopsided."
—HARRY H. GOODE, *Electrical Engineering Dept., University of Michigan, Ann Arbor, Mich.*

THE ENGINEER'S

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Recent Books

Basic Human Factors for Engineers. *By Paul A. Verdier; 103 pages, 5½ by 8¼ in., clothbound; published by Exposition Press Inc., 386 Fourth Ave., New York 16, N. Y.; $4.00 per copy.*

A practical method of task analysis is presented. The method explains basic facts of applied psychology in symbolized form—what human factors are, how to flag them out, and how to utilize them in solving engineering problems.

Subjects include designing equipment and systems for optimum human usage, organizing a human-engineering department, human-factors working forms, performance-test scoring and diagnosis, and personnel evaluation.

Thermoelectric Materials and Devices. *Edited by Irving B. Cadoff and Edward Miller, Dept. of Metallurgical Engineering, New York University; 344 pages, 6¼ by 9¼ in., clothbound; published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; available from* MACHINE DESIGN, *$9.75 per copy postpaid.*

Recent progress in development of new materials for thermoelectric devices is surveyed. Book is based on series of lectures presented at New York University.

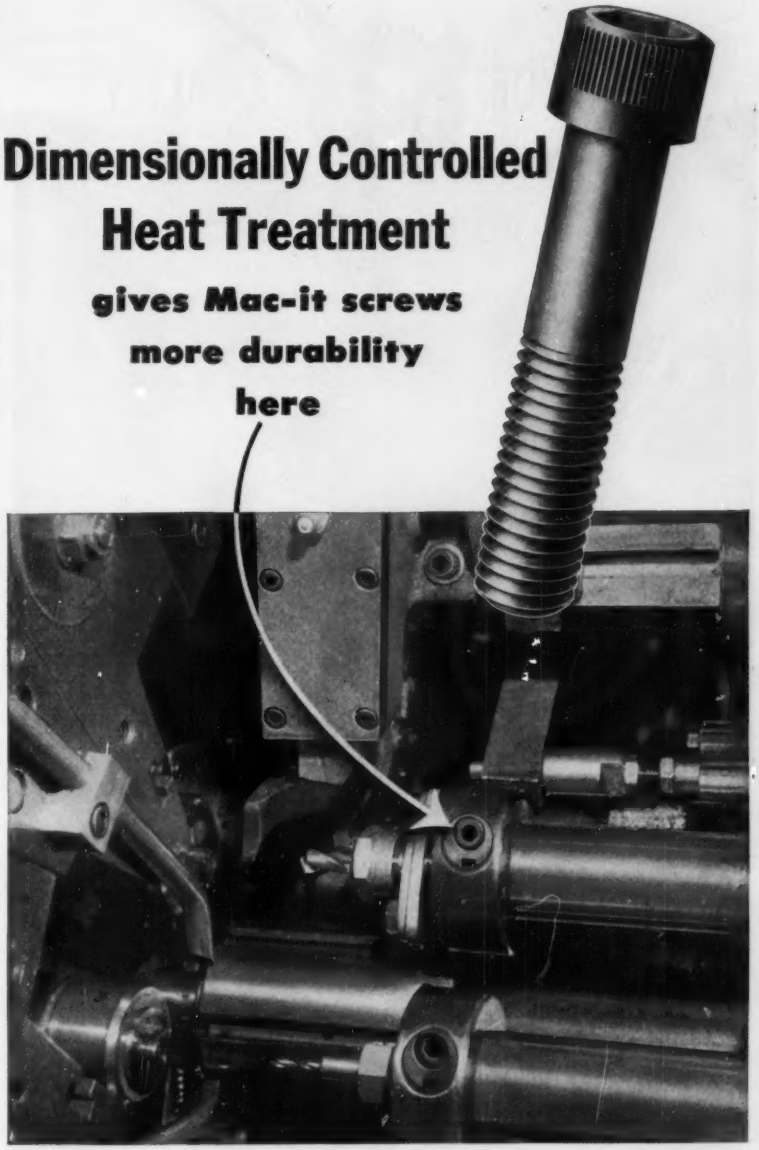
First section deals with theory of thermoelectric processes and circuits. Next, a general evaluation of materials is presented. Ensuing chapters discuss materials currently being used and those being considered for future use. Last section concerns principles of device design and descriptions of some experimental and prototype units which have been built and evaluated.

Machine Drawing and Design. *By W. Abbott; 281 pages, 6 by 9 in., clothbound; published by Blackie & Son Ltd., 17 Stanhope St., Glasgow, Scotland; $3.25 per copy.*

A short review of mechanical drawing is followed by an introduction to the design of the more com-

Dimensionally Controlled Heat Treatment

gives Mac-it screws more durability here



The heat treatment specifications for every Mac-it alloy steel screw are determined by its dimensions as well as its intended use.

At Mac-it, large and small diameters are not run through the heat treating processes indiscriminately. Instead, our metallurgists establish a heat treating cycle for each type and size. This assures that every screw has the proper combination of strength, toughness, ductility and resistance to vibration and shock.

Dimensionally controlled heat treatment is just one illustration of the care which is taken in every step in the manufacture of Mac-it screws. That's why Mac-its *hold tight in a tight place.*

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NEW SPECIFICATION SHEET listing new 1960 Series Socket Screw Industry Dimension Standards. Write for your *free* copy.

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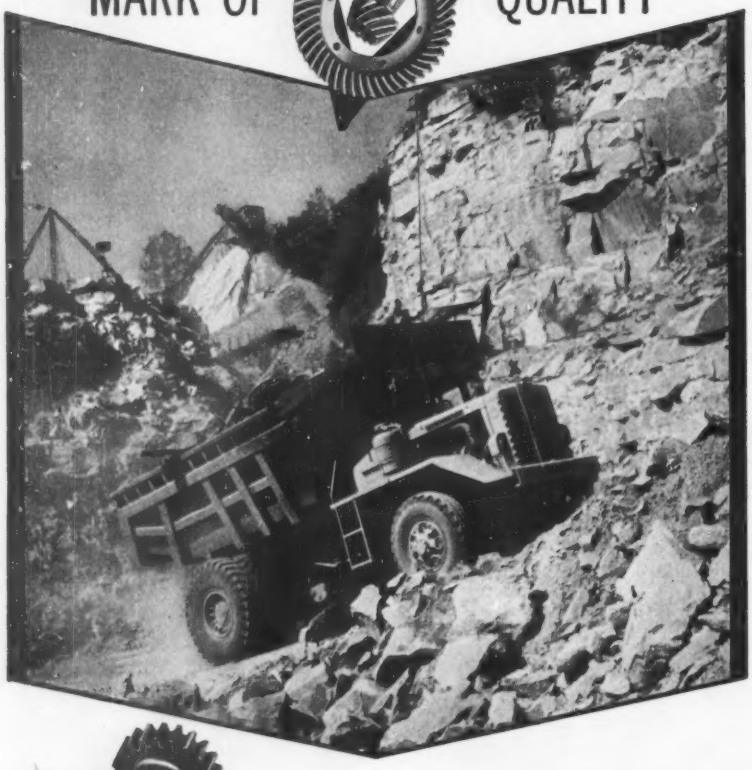

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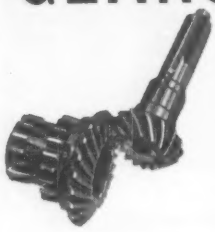

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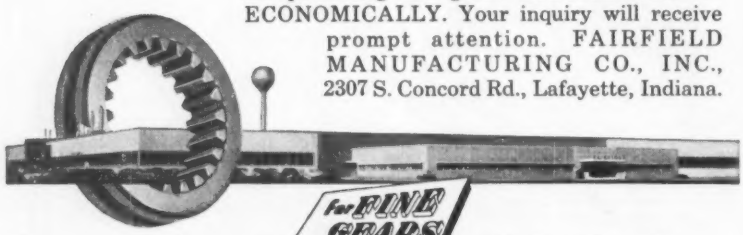

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mon details of machinery. This seventh edition has been largely rewritten to include material not covered in the sixth edition of 1954.

Such topics as factors of safety, fasteners, shafts and fittings, bearings, brakes and clutches, gears, and valves and engines are discussed. Exercises in drawing and design are also included.

New Standards

American Standard, ASA B1.1-1960, Unified Screw Threads. *150 pages, 8½ by 11 in., paperbound; published by American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; available from American Standards Association Inc., 10 East 40th St., New York 16, N. Y.; $5.00 per copy.*

Interchangeability of screws and fasteners among equipment produced by Canada, Britain, and the United States is covered. This revision of the 1949 standard contains a new arrangement of tables to increase convenience of use, addition of classes 3A and 3B in all standard thread series, changes in designations, and increase in internal-thread minor-diameter tolerances for classes 1B and 2B to encompass additional tap-drill sizes.

American Standard, ASA B54.1-1960, Identification Code for Ball and Roller Bearings. *44 pages, 8½ by 11 in., paperbound, stapled; published by American Standards Association Inc., 10 East 40th St., New York 16, N. Y.; $4.00 per copy.*

Identification codes for radial and thrust types of ball and roller bearings are presented. Codes include basic number, modification of design, clearances and tolerances, lubricants and preservatives, and special requirements. More than 50 tables are used to simplify presentation of information.

American Standard, ASA Y14.15-1960, American Drafting Standards Manual: Section 15—Electrical Diagrams. *20 pages, 8½ by 11 in., paperbound, stapled; published by American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; available from American Standards Association Inc., 10 East 40th St., New York 16, N. Y.; $1.50 per copy.*

Definitions and general information applicable to most of the commonly used electrical diagrams are

presented. Detailed recommendations concerning preferred practices in preparation of these diagrams are included.

Association Publications

Third Pacific Area Meeting Papers: Symposium on Fatigue of Aircraft Structures. 138 *pages, 6 by 9 in., clothbound; published by American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.;* $4.00 *per copy.*

Included in the nine papers are basic discussions of such topics as cumulative damage, crack-propagation rates, and effect of biaxial stressing. Advanced discussions on design and test for handling spectrum-type loading, sonic fatigue, and high stress, low-cycle fatigue are also included.

Maintaining the Product Portfolio: The Commercial Development Concept. 87 *pages, 6 by 9 in., paperbound; published by American Management Association, 1515 Broadway, New York 36, N. Y.;* $2.25 *per copy.*

Basic functions of commercial development are discussed—whether a market exists for a new product, estimating size at various price levels, introduction and initial sale of new products, and special studies in commercial aspects of the company.

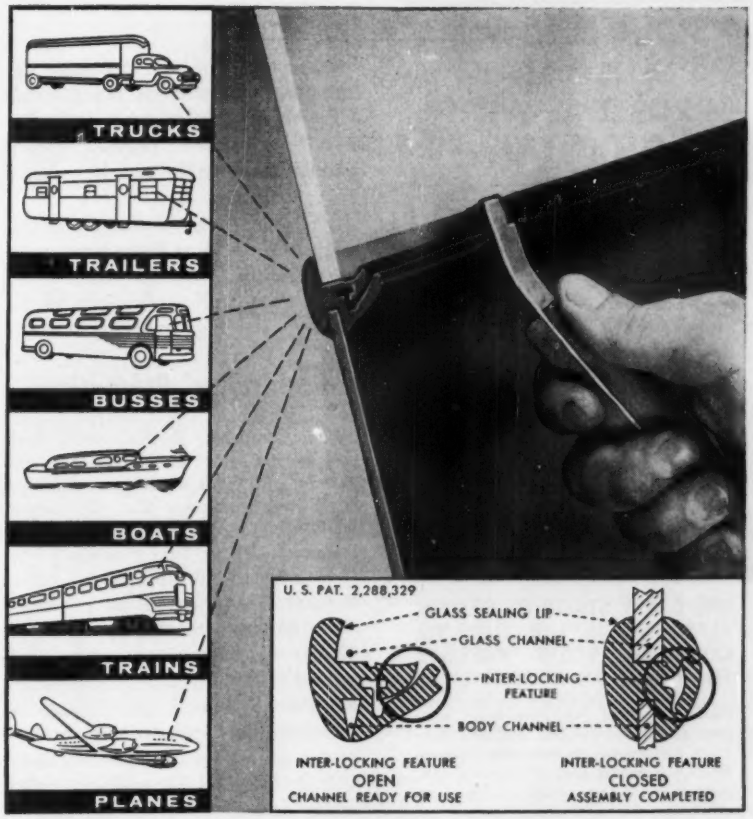
Importance of commercial development to product planning is described. A case study shows how one company met its objectives by utilizing a successful technology team.

Glossary of Terms for Fluid Power: 2nd Edition—1960. 31 *pages, 8½ by 11 in., paperbound, stapled; published by National Fluid Power Association, 5595 N. Hollywood Ave., Milwaukee 17, Wis.;* $1.00 *per copy.*

About 400 terms related to fluid power are defined. Flow, fluids, cylinders and parts, compressors, motors, sealing devices, controls, and instruments are covered. An index is included to simplify usage.

Ultrasonic Welding. *Edited by Arthur L. Phillips, 38 pages, 6 by 9 in., paperbound, stapled; published by American Welding Society, 33 West 39th St., New York 18, N. Y.;* $1.50 *per copy.*

Ultrasonic welding produces a metallurgical bond without arc or



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Its *one-piece* design locks and seals in one operation. No extra locking-strip needed. It's the faster, simpler method for mounting glass in any type body panel—truck, trailer, bus, boat, train, plane, etc.

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Compounded for maximum weather resistance and extra long life. Close durometer tolerances are held for uniformly tight seal against moisture and surest possible locking. These rubber channels can be positioned first on *either* glass or body panel. All details are shown in illustrated brochure gladly sent on request.

Ordered and re-ordered by the most prominent body builders, this Self-Locking Channel is another example of the creative thinking and ingenuity behind rubber parts by Continental. When you need rubber parts to do a specific job, call a rubber specialist *during the planning stage.* This often makes for economy as well as better end results. Call Continental —rubber specialists since 1903.

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Circle 588 on Page 19

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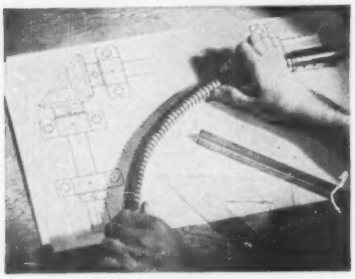

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Use of standard or specifically designed power drive flexible shafting reduces or eliminates alignment and maintenance problems . . . does away with complex and expensive arrangements . . . removes danger of exposed moving parts.

CHECK THESE ADVANTAGES:

- **Simplicity of Design**—greater freedom to locate components . . . ideal for connecting components having relative motion.
- **High Efficiency**—ranging from 80% to 95%.
- **Safety**—replaces exposed universal joints and shafts in hazardous locations.
- **No Alignment Problems**—accuracy of alignment, so important on conventional drives, is not required.

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Circle 589 on Page 19

spark, melting of base metals, or deformation of materials being welded. Many similar and dissimilar metals which were previously considered unweldable can be welded by this process.

Fundamentals, metals which can be welded, welding techniques, weld characteristics, quality control, equipment, and applications of ultrasonic welding are covered.

Manufacturers' Publications

Book Computer. *By Kirk Finley Carlsten and Karsten Gene Hellebust; 900 pages, 8 by 10¼ in., clothbound; published by Metron Instrument Co., 432 Lincoln St., Denver, Colo.; available from* MACHINE DESIGN, *$15.00 per copy postpaid.*

Complete multiplication tables through 999 times 999 are presented with accuracy to six-digit answers. Tables were computed and tabulated on IBM electronic computing equipment. Such calculations as multiplication and division, squares and square roots, reciprocals, logarithms to base 10, and circumferences and areas of circles can be made.

Motorola Power Transistor Handbook. *Edited by Ralph Greenburg; 205 pages, 6 by 8½ in., paperbound, plastic-ring binder; published by Motorola Semiconductor Products Inc., 5005 E. McDowell, Phoenix, Ariz.; $2.00 per copy.*

Power-transistor theory, design, and applications are covered. Mechanical, electrical, and thermal characteristics of power transistors are analyzed. Selection charts, representative specifications, power-transistor outline drawings, and derating curves are included for industrial and military transistor types.

RCA Pencil Tubes. *27 pages, 8½ by 11 in., paperbound, stapled; published by Radio Corp. of America, Commercial Engineering, Electron Tube Div., Harrison, N. J.; $0.50 per copy.*

Design features of pencil tubes, application to systems, and considerations for electrical and mechanical circuit design are presented. A tube-data section covers available commercial and military pencil-tube types, and includes data on dimensions, ratings, operating values, and intended uses.

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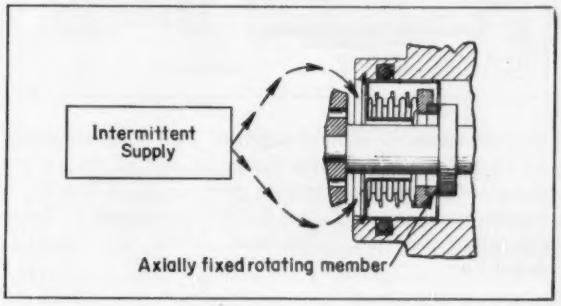
NOTEWORTHY

Patents

Wet-Dry Shaft Seal

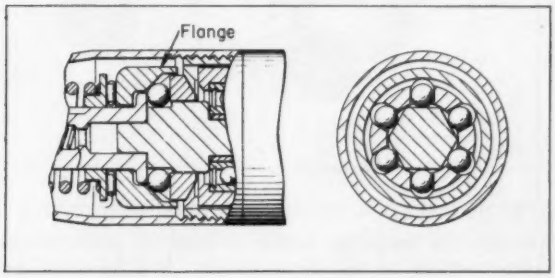
Shaft seal, which is normally lubricated and cooled by system hydraulic fluid, will not burn out when the fluid is cut off. The sealing pressure is controlled by



the fluid pressure; when fluid pressure is cut off, the sealing surfaces are held in only light contact by a spring. *Patent* 2,957,711 *assigned to Thompson Ramo Wooldridge Inc., Cleveland, Ohio, by Leslie L. Aspelin.*

Rolling-Impulse Clutch

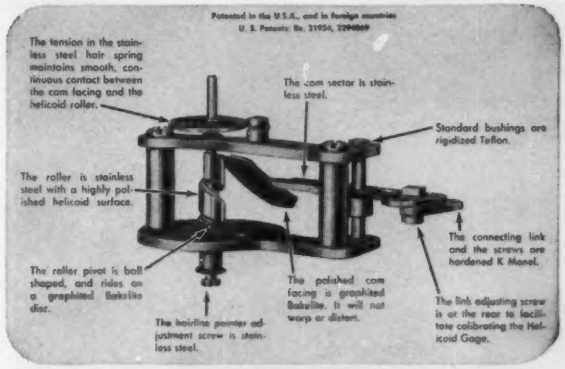
A polygonal cam acts on a number of radially disposed balls to transmit rotary power through a torque-responsive clutch. A circular flange with a beveled shoulder maintains the balls in proper contact to provide coupling action. When the applied torque exceeds



a predetermined level, the balls are forced up into inclined bores. The cam then passes under the balls until the torque is released. *Patent* 2,957,323 *assigned to Reed Roller Bit Co., Houston, Tex., by Charles H. Elliott and Richard E. Eckman.*

Magnetic Coupling-Brake

An electromagnet is used to disengage a permanent-magnet shaft coupling that may also function as a brake. The coupling is held in engagement by the permanent magnets. Magnetic flux produced by en-


Patented in the U.S.A., and in foreign countries
U. S. Patents: Re. 21934, 2290869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is stainless steel.
Standard bushings are rigidized Teflon.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The helicline pointer adjustment screw is stainless steel.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.

Exclusive Helicoid movement provides *Sustained Accuracy* ...on the toughest jobs!

• Helicoid Gages have no gears, no teeth—wear is reduced to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Even when subjected to violent pressure pulsations or mechanical vibrations, Helicoid Gages *stay* accurate. Only Helicoid Gages provide *all* these advantages:

Sustained accuracy—Helicoid movements have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy. Conventional *geared* gages on the same test became useless after only 500,000 cycles.

Durability—Bourdon tubes won't stretch, leak or crack. Dial faces won't corrode or chip.

Wide selection—Gages are available for practically any application from tap water to acid. Gages include flanged and flangeless, round and square, in standard and flush-mounting models. Accessory equipment includes gage cocks, needle valves, siphons and snubbers.

NEW! Solid-Front Safe-T-Case Gage

This new Helicoid design diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming the back cover plate, which can then be replaced inexpensively.

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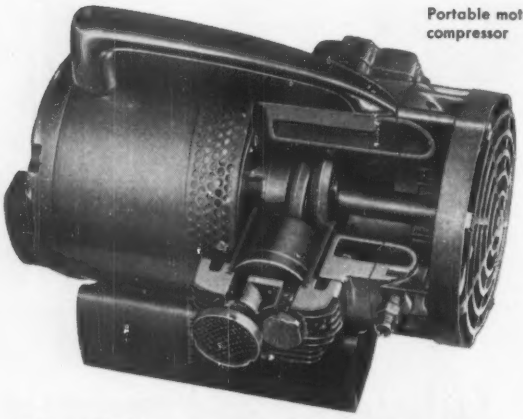
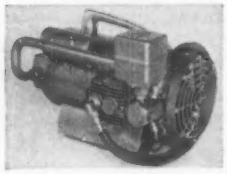


Portable motor compressor

B&G® COMPRESSED AIR COMPLETELY *Oil-Free*

58 models to select from

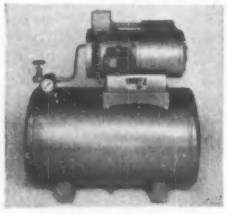


Tankless motor compressor

There's never any oil-spoiled work with B&G Compressors—they *never need oiling.* Powered by B&G built motors, they are constructed with carbon graphite piston rings and skirts which need no lubrication; bearings are grease-packed and sealed for life.

Numerous additional design and construction features assure long-lived, dependable delivery of cleaner, cooler, drier air and smooth operation.

You'll find the compressor you need in the B&G line! Choose from 58 models—lightweight portables, bare compressors, tankless motor compressor outfits, air tank motor compressor outfits; from $\frac{1}{12}$ to $\frac{3}{4}$ HP, up to 6.57 CFM, pressures to 190 psi.



Air tank motor compressor outfits

Gasoline engine-driven compressor outfits

PULLS UP TO 28" OF VACUUM... CONTINUOUSLY

B&G Vacuum Oil-less Vacuum Pumps are free of expensive lubrication maintenance and do away with messy oil-laden discharge vapors.

Two B&G Vacuum Pumps are integral components of this vacuum lifter which handles 2,000 lb. metal sheets.

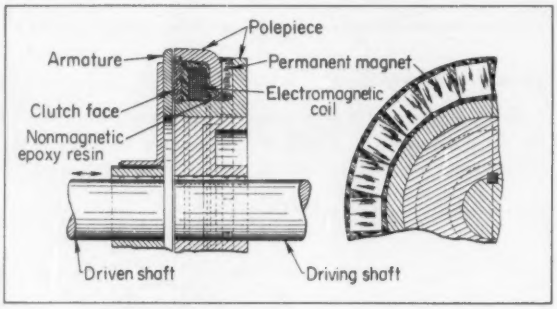
Send for Catalog GO-259

***Oil-less* AIR COMPRESSORS**

BELL & GOSSETT COMPANY

Dept. GL-67, Morton Grove, Illinois

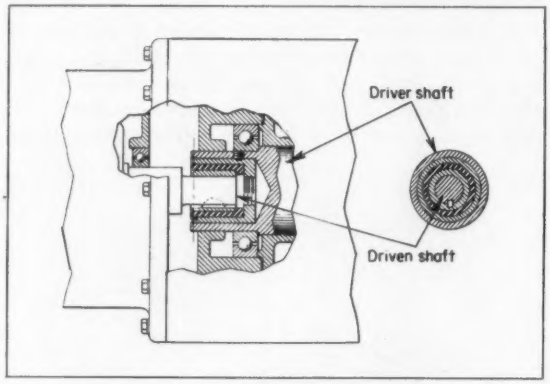
ergizing the electromagnetic coil cancels out the flux from the permanent magnets to disengage the coupling. The permanent magnets have a high permanence characteristic, so that the flux-bucking action of the electromagnet does not demagnetize them. The entire



magnet assembly is held together with a nonmagnetic epoxy resin. A bevel on the inner end of the curved polepiece prevents a magnetic short circuit of flux across the two polepieces. *Patent* 2,956,658 *assigned to Eaton Manufacturing Co., Cleveland, Ohio, by Ralph L. Jaeschke.*

Nested Flexible Coupling

A flexible coupling allows a minimum of axial space between close-coupled driving and driven units. The driven shaft fits into the center of the coupling, and is held firmly by a press fit, key, or setscrew arrangement. A hole drilled in the end of the driving shaft

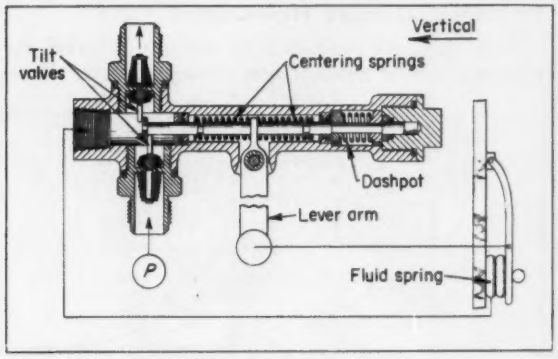


accepts the coupling, which is held in place in the same manner as the driven shaft. A bonded molded rubber layer between inner and outer annular sleeves absorbs vibrations and allows the transmission of substantial torsional loads. *Patent* 2,956,187 *assigned to General Electric Co., Schenectady, N. Y., by Winchester A. Wood.*

Self-Leveling Fluid-Spring Suspension

Leak-proof leveling valve for a fluid-spring suspension uses a pair of tilt valves and a damped actuating rod. When excess load causes the lever arm to move from its central position, one of the tilt valves is opened, admitting pressurized fluid to the spring until the arm is

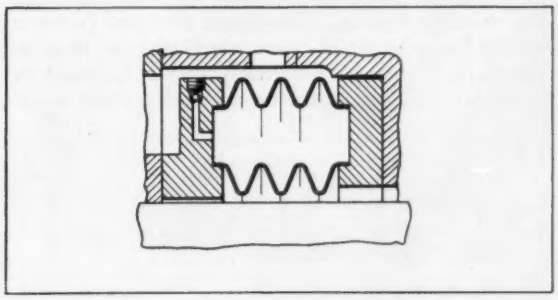
again centered and the suspension is leveled. If the load is removed, the lever arm moves to open the second tilt valve, releasing the excess pressure from the spring to maintain level position of the suspension.



A dashpot insures that the tilt valves are opened only when the load is applied for a preset time, eliminating the possibility of value flutter caused by vibration or shocks. *Patent* 2,957,705 *assigned to Thompson Ramo Wooldridge Inc. by Edward J. Herbenar.*

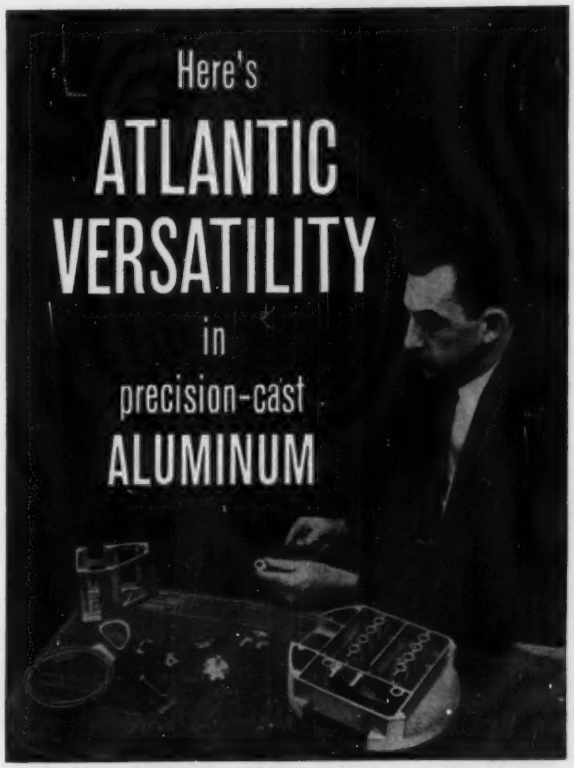
Thermal Load Balancer

Excessive heat generated by high thrust loads actuates a bellows to relieve the loads on thrust bearings. A cooling fluid fills the chamber. As heat is generated by thrust loads, the coolant volume increases and forces the bellows to expand axially, thus generating a force to counteract the thrust loads. As a safety fea-



ture to guard against overloading of the bearing by the balancer, a ball check valve is used to relieve excessive pressure. When the pressure returns to normal, a partial vacuum is formed in the chamber, causing the check valve to open for passage of additional coolant to the chamber. *Patent* 2,956,843 *assigned to Borg-Warner Corp., Chicago, Ill., by Roy T. Burgess.*

High-speed thrust bearing minimizes number of precision machined parts to avoid fitting problems due to accumulation of tolerances. Bearing construction maintains the longitudinal position of a rotating assembly through inner and outer thrust plates which fit into a shoulder, providing spaced opposed bearing faces. Provision is made for lubricating the movable



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Tooling costs will average 20 to 25% that of comparable die castings.

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Circle 592 on Page 19

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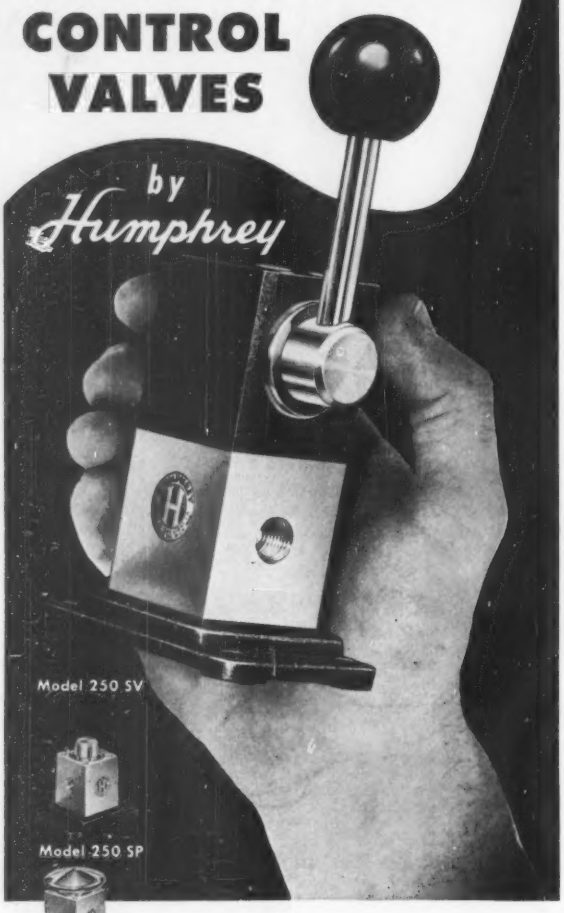
CONTROL VALVES

by Humphrey



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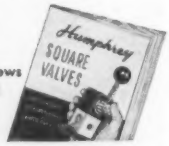
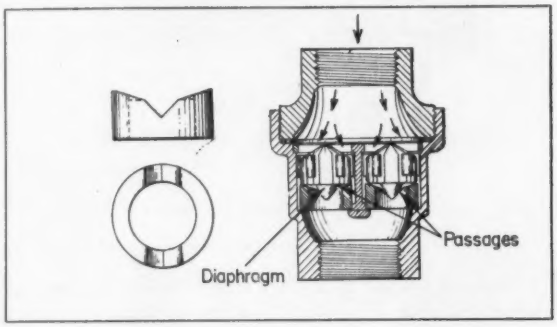


thrust faces. *Patent* 2,953,416 *assigned to The Garrett Corp., Los Angeles, Calif., by Jerome Collins, Hugh MacIrnes, and Wilton E. Parker.*

Pressure-Responsive Flow-Control Valve

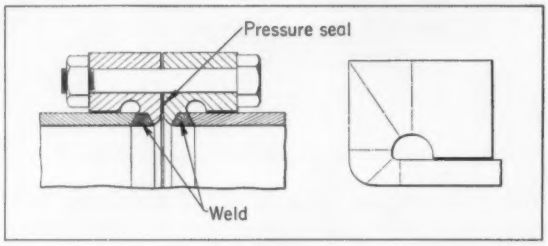
Fluid passages controlled by pressure-actuated diaphragms provide constant flow through a valve. When



pressure rises above a predetermined level, the diaphragms are forced down into the flow passages, creating a constriction. The conical diaphragm construction assures smooth flow through the passages and permits the fluid to center the diaphragms in the flow passages. *Patent* 2,957,496 *assigned to Hays Manufacturing Co., Erie, Pa., by Raymond J. Bartnik.*

Stress-Compensating Pressure Flange

Twisting forces produced by internal pressure loads in a pressure vessel are absorbed by stress-compensating coupling flanges. The flange structure (see schematic) forms a curved beam whose effective cross sectional depth increases progressively from the vessel wall outward. The arrangement eliminates sharp corners



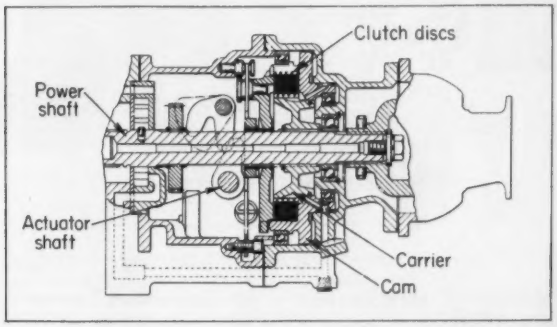
and abrupt sectional area changes, particularly at the internal juncture of the connection between the cylinder and the flange, where stresses usually tend to concentrate. *Patent* 2,956,821 *assigned to American Radiator & Standard Sanitary Corp., New York, N. Y., by Townsend Tinker.*

Brake Booster

Power assistance for braking is provided by a booster unit as long as the vehicle is moving, regardless of engine power. The driveshaft of the vehicle is connected to the power shaft of the booster assembly. Force

Circle 593 on Page 19

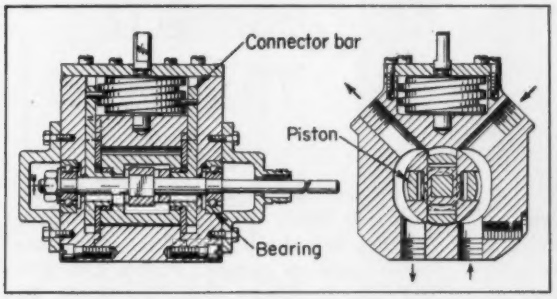
applied to the brake pedal rotates an actuator shaft to engage a clutch which connects a cam and carrier assembly to the rotating power shaft. The cam operates a piston (not shown) on each side of the unit, which furnishes fluid under pressure to the brake cylinders.



The booster-assembly clutch is designed to provide slippage between the discs in proportion to the pressure applied to the brake pedal. *Patent 2,995,426 assigned to General Motors Corp., Detroit, Mich., by Lothrop M. Furbush and Roland V. Hutchinson.*

Reversible Adjustable-Displacement Pump

Pins fastened to connector bars ride in the grooves of an adjusting screw to provide adjustment of fluid delivery from a rotary pump, even while the pump is in operation. The connector bars ride in slots, and are fastened to support cylinders which position the piston bearings. Moving the bars varies the amount of eccentricity of the bearings with respect to the shaft, thus controlling the effective displacement of the pump. Direction of flow through the pump can be reversed by shifting the position of bearing eccentricity from one side of the shaft to the other or by reversing the direction of rotation of the rotor. *Patent 2,953,098 assigned to Royal Electric Inc., Xenia, Ohio, by Raymond W. Boyer.*



Hub-Shaft Coupling

A coupling for joining a hub to a shaft is made up of two ring sections, prestressed and locked together by an annular tab. Axial pressure on the ring assembly provides an internal-external gripping action. Construction avoids uneven stress distribution and stress concentrations. The inner mating surfaces of the ring

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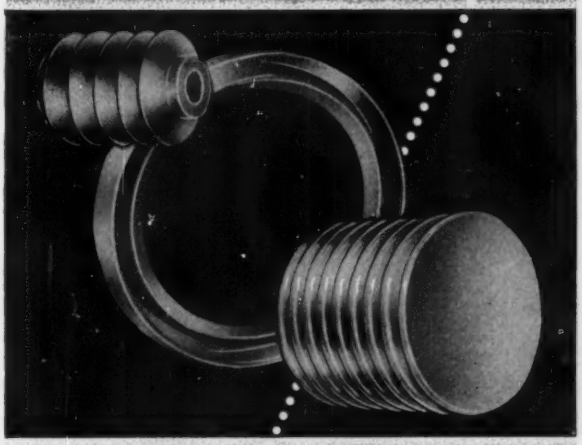

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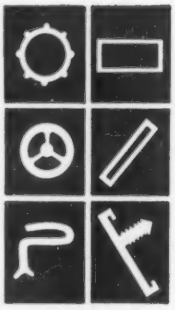

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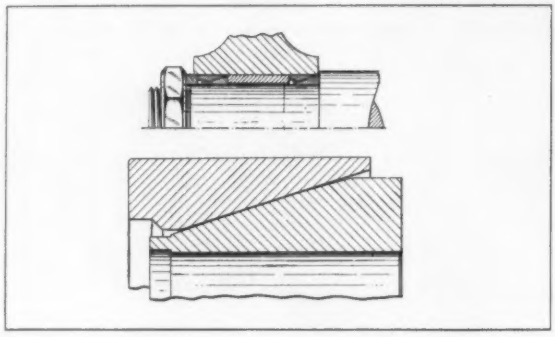
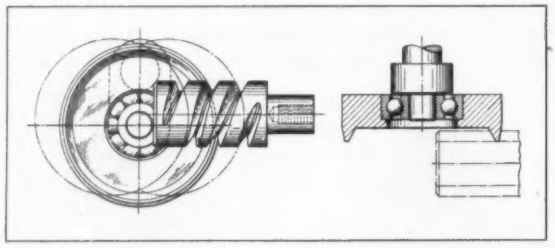
sections are slightly convex to insure even wedging contact. Permanent preassembly of the unit prevents gouging of the hub from misalignment, and reduces the



possibility of abrasion due to foreign matter between mating surfaces. *Patent 2,956,826 assigned to U. S. Automatic Corp., Amherst, Ohio, by Eric T. Nord.*

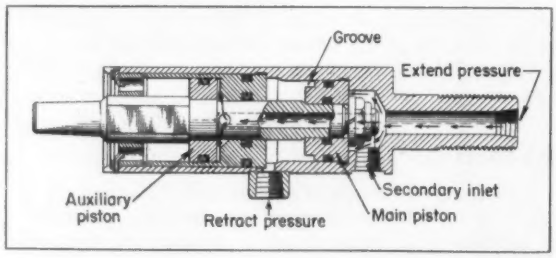
Partial-Revolution Worm-Gear Drive

A face gear with a single circular tooth provides a variable velocity ratio over a partial revolution and allows the transmission of substantial loads without excessive wear. The face gear is mounted to a crank on the output shaft. As the gear is displaced from its central position, the velocity ratio between it and the



driving worm becomes progressively smaller. The flanks of the circular tooth have concentric concave and convex surfaces, and the flanks of the worm are formed to provide complete contact. *Patent 2,953,031 assigned to The Gleason Works, Rochester, N. Y., by Edward F. Elman and Charles B. King.*

Dual-Piston Fluid Cylinder



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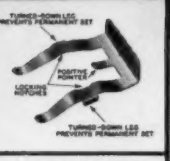

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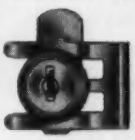

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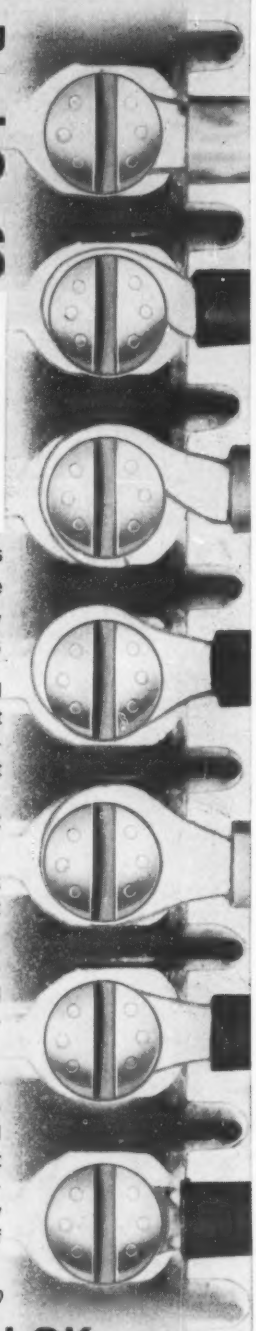

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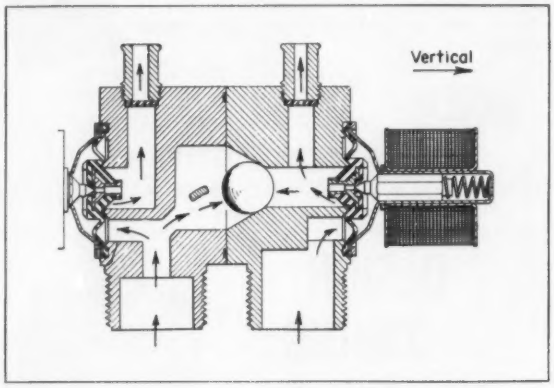
pneumatic-hydraulic cylinder to assure immediate response. When pressure is applied during the extension cycle, as shown, the fluid acts on the surface of the main piston and is ducted to the corresponding working area of an auxiliary piston. The retract pressure inlet allows fluid to drain from the retract chamber. During the retract cycle, fluid under pressure flows through the inlet and acts on the reverse side of the main piston. A groove on this surface assures immediate response of the piston during the retract cycle. *Patent* 2,956,549 *assigned to General Motors Corp., Detroit, Mich., by Harry C. Malpass.*

Three-Way Valve

Separate solenoids control two diaphragms to provide any of three combinations of water flow in a mixing valve. Energizing one solenoid (shown) causes the diaphragm to lift from its seal, allowing flow of cold water from inlet to outlet. The other solenoid and its diaphragm control hot water flow. For warm water



flow, both solenoids are actuated together. Because the hot water outlet is larger than that for cold water, the pressure is greater on the cold side of the ball, keeping it from seating. Thus, warm water issues from what is normally the hot water outlet. *Patent* 2,955,688 *assigned to General Electric Co. by Aiden M. Stone.*

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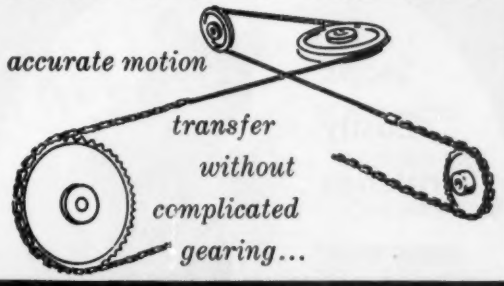

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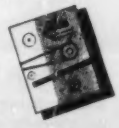

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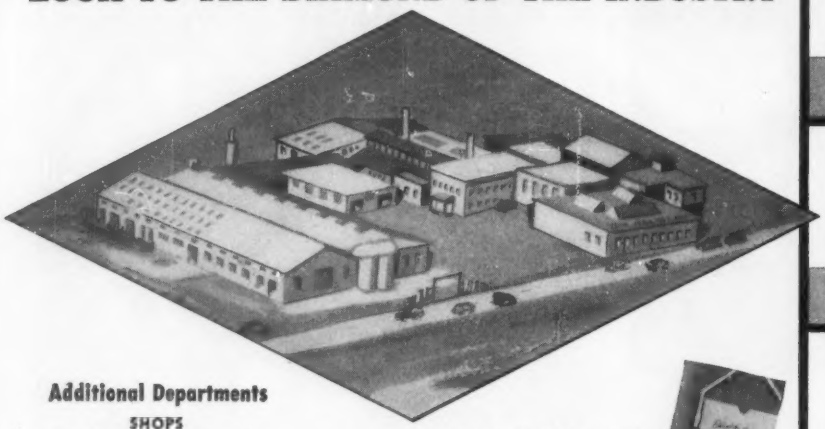

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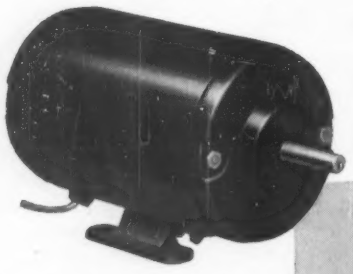

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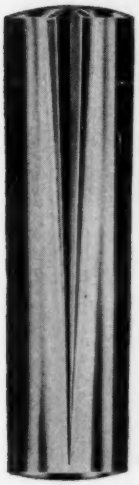

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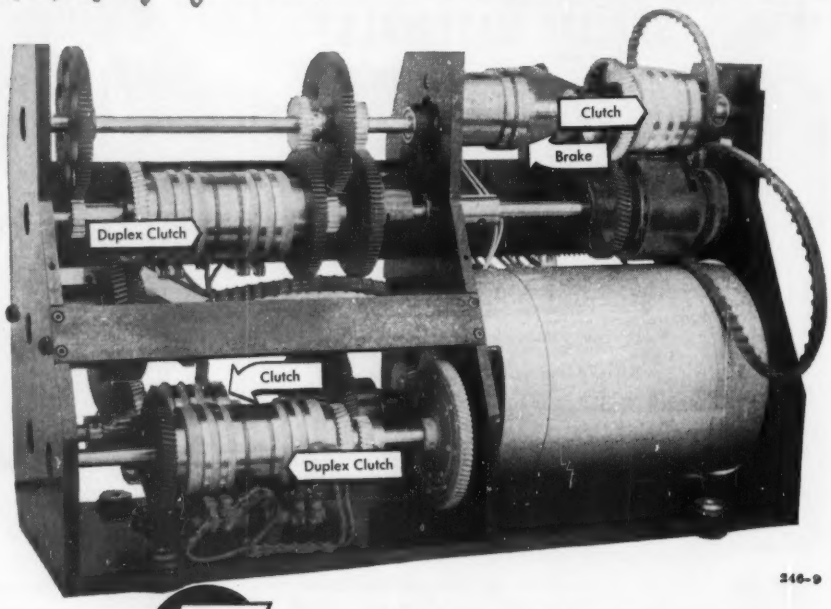

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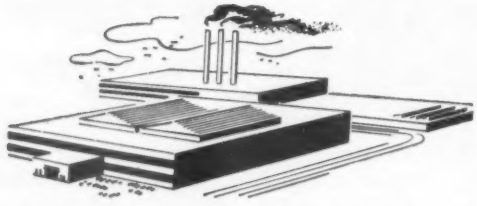

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50 YEARS IN A CLIP JOINT MAKE ONE FINE CATALOG!

Recently, Mueller Electric Company celebrated its 50th Anniversary. Our sole product is the electric clip...the best tool in the world for quick test connections.

Our latest clip catalog is jam-packed with the fruit of these 50 years' work. The right test clip for every electrical maintenance job can save more work and more time than you think!

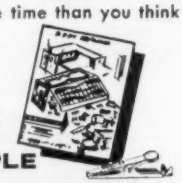


ILLUSTRATION ½ ACTUAL SIZE

Write factory today for **FREE COPY OF LATEST CATALOG...FREE SAMPLE OF "MINI-GATOR" CLIP**

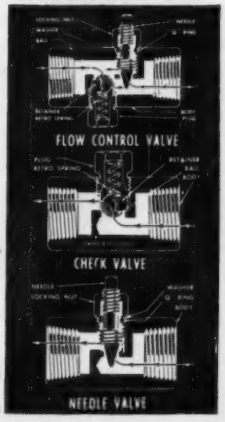
A Company With A Tradition...And A Future
Mueller Electric Co.
1589Q EAST 31st STREET • CLEVELAND 14, OHIO

Circle 611 on Page 19

Get Easier, More Accurate Cylinder Speed Control

with **Pneu-Trol®** VALVES IN AIR OR HYDRAULIC USE

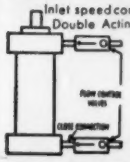
2,000 (brass or aluminum) and 5,000 (steel) p.s.i.



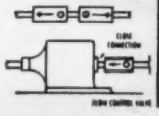
Pneu-Trol Valves combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to seat, requiring only a slight differential pressure to fully open or close it. Check Valve and Needle Valve incorporate single function features of Flow Control Valve. All valves available in 5 female pipe sizes — ⅛" to ¾". Valve bodies are made from brass, aluminum, steel or stainless steel. Attractive Prices — Immediate Delivery.

Write for Illustrated Circular and Price List.

Inlet speed control for Double Acting Cylinder.



Single Acting Cylinder Speed Control.



AUTOMATION AUTO-PONENTS INC. COMPONENTS

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Circle 612 on Page 19

IT'S NEW... IT'S MONO-RACE''®

LARGE BALL BEARING CONNECTIONS THAT ROTATE UNDER LOAD

DOES TWO JOBS IN ONE—a load bearing member . . . and a connection that reduces the wear, maintenance and adjustment of center pin and roller designs.

BUILT TO YOUR SPECIFICATIONS AT THE LORAIN PLANT. All operations—machining, grinding the races, hardening, and gear cutting—are under rigid control.

DESIGN FIELD-TESTED FOR 10 YEARS. "Mono-Race" is similar to the famous "Shear-Ball" connection used successfully on Lorain shovel and cranes for 10 years.

MONO-RACE IS AVAILABLE IN 2 TO 12-FT. DIAMETERS in a wide range of mounting arrangements. Ball sizes 1 inch in diameter and up. Write for details.

MONO RACE DIVISION
TRADE MARK
THE THEW SHOVEL COMPANY, LORAIN, OHIO

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TA "King-Size" Instrument Cases 4 PAGES

TA Standard Instrument Cases 20 PAGES

Learn how TA's new predesigned Instrument Cases solve *your* equipment housing problems.

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THESE EXCLUSIVE FEATURES—STANDARD WITH TA—SAVE YOU TIME AND COST

1. Predesigned panel-layouts for perfect fit.
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11. TA Cases are color matched to, and integrated with, the instruments they are to contain.

INSTRUMENT MANUFACTURERS: If you make portable instruments or equipment, you can't afford *not* to investigate the TA line.

TA Cases come in a diversity of standard lid sizes, and are sold at proprietary prices. During assembly the depth can be cut to your exact specifications. Or, if you like, TA will furnish you free vellums and templates so you can save yourself money by designing your product to fit one of the many standard sizes.

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(or call CH 5-3748)
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Circle 613 on Page 19

IDEAS!
for heavy equipment designers

Looking for new solutions to heavy-duty power problems? This new brochure has full information on heavy-duty transmissions with input torque capacities of 150 to 2500 ft-lb. Included is "idea material" describing:

- Standard transmissions customized to each application
- Wide variety of "engineered-to-order" transmissions
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Send coupon for your free copy . . . or see our Catalog in *Sweet's Product Design File* today!

Cotta Transmission Co., 2340 - 11th Street, Rockford, Illinois
Please send my copy of "Cotta Heavy-Duty Transmissions" to

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Company_____

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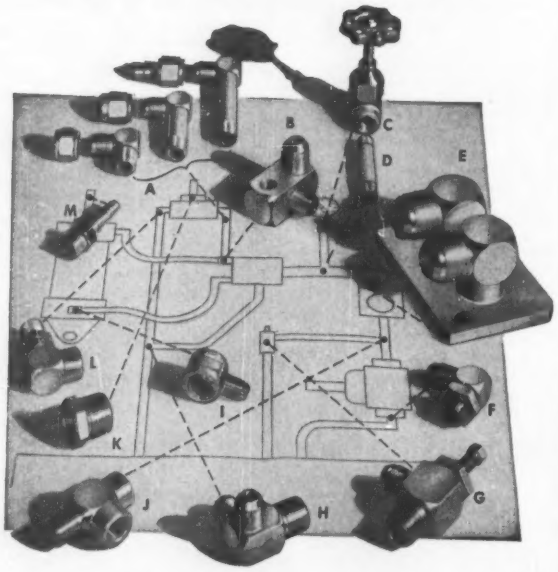
Circle 615 on Page 19

Choose from a COMPLETE LINE of steel fluid power fittings and accessories



A—JIC Flare Tube Fittings	G—Ball Check Valve
B—Manifold Fitting	H—Lateral Outlet Fitting
C—Needle Valve	I—Universal Elbow
D—Pipe Nipple	J—Dryseal Pipe Fitting
E—Flange Manifold	K—Hex Reducing Bushing
F—Straight Thread, "O" Ring Seal Fitting	L—Swivel Elbow
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You can depend on L & L's quality, availability, and selection of steel couplings for piping all industrial hydraulic circuits.

Write for more information on items of interest to you

L and L Manufacturing Company

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Connect with DEPENDABLE L&L

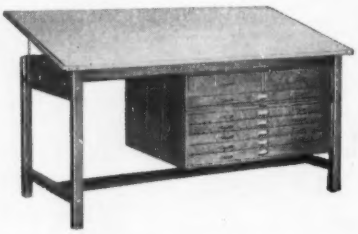
Distributors in Principal Cities

MAYLINE

Mayline Space Saving Wood Drafting Furniture!

For greater efficiency in the drafting room install Mayline wood drafting furniture.

With wood 4-Post tables, supplemented by wood plan files, there are seven possible space saving combinations. For complete particulars and prices see your dealer, or, write to factory for Folders S-17 and S-20.



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Subsidiary of **BENRUS WATCH COMPANY, Inc.**

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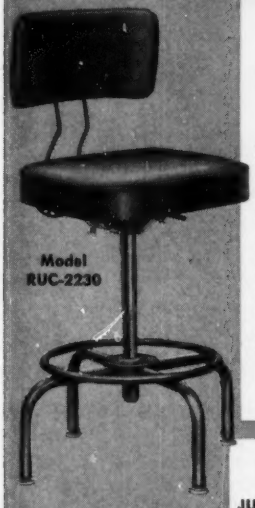
Circle 616 on Page 19

Circle 618 on Page 19

COMFORTABLE, UPHOLSTERED, ADJUSTABLE DRAFTING CHAIRS



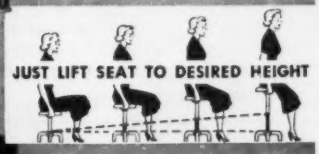
- 2 inch upholstered seat
- Full swivel seat
- 2-way adjustable backrest
- No soiled hands when adjusting seat
- Three sizes: 20" to 28"—24" to 32"—28" to 36"
- Gray, green, beige or brown finish

Also available with round metal or wood seat; or formed plywood or solid hardwood saddle seat.

FREE TRIAL

Use an AJUSTRITE chair or stool for 30 days without obligation. Prove to yourself the many advantages AJUSTRITE offers in comfort, utility and economy. Write today—we'll do the rest.

10 YEAR GUARANTEE



12 Models for Factories • Schools • Laboratories • Hospitals • Offices

AJUSTRITE CHAIRS AND STOOLS

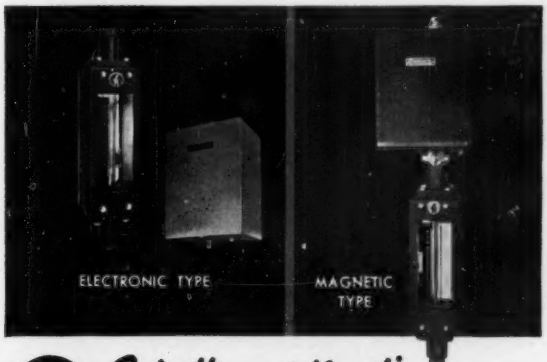
AJUSTO EQUIPMENT CO.
Bowling Green, Ohio

Circle 619 on Page 19

ALARM ROTAMETERS

SIGNAL ABNORMAL FLOW RATES

SK Alarm Rotameters accurately measure fluid rate of flow—activate a light or alarm device, start or stop a pump, motor, control unit *in case of abnormal flows*. They are accurate, economical, dependable. Get details in new Bulletin 18A.



Schutte and Koerting COMPANY
INSTRUMENT DIVISION
2277 STATE ROAD, CORNWELLS HEIGHTS, BUCKS COUNTY, PA.
EXPORT DEPT.: 1505 Race Street, Philadelphia 2, Pa., U.S.A.

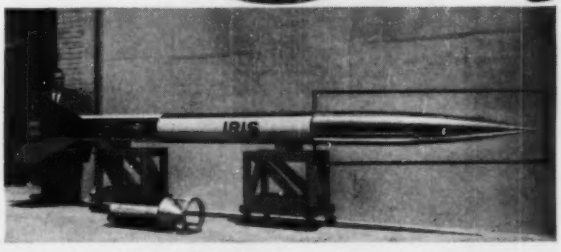
Circle 620 on Page 19

Spincraft experience in space can mean down to earth savings for you...

Spincraft, with over a decade of missile experience, was a natural supplier for contractors on two recent rocket projects. One, the IRIS, was large; the other, NIKE CAJUN, was small.

Only Spincraft's kind of experience and equipment could fashion these tapered aluminum cones to the exacting tolerances required. Therefore, Spincraft's unique skill is constantly being applied to the solution of unusual metal-forming problems.

Investigate Spincraft — it can mean improved design and lower cost. Send your prints or phone for a Spingineer to visit you.



Write for Notes For An Engineer's File, a series of valuable bulletins.

Spincraft
SKILL WILL DO IT
INCORPORATED

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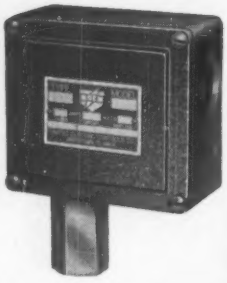
Circle 621 on Page 19

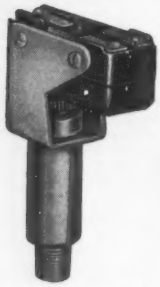
UNITED ELECTRIC

Multi-Purpose

PRESSURE CONTROLS J7 | J40

▶ Enclosed-TYPE J7





▶ Skeleton-TYPE J40

These controls are compact, precision-built, rugged and inexpensive. Type J7 is ideal for controlling air, gas or liquid pressures up to 500 psi . . . Type J40 for pressures up to 250 psi.

Adjustable Pressure Ranges	J7 . . . various models cover ranges between limits of 0 and 500 psi J40 . . . various models cover ranges between limits of 0 and 250 psi
Switch Ratings	15 amps or 20 amps at 115 or 230 volts A.C., also D.C. switches upon specification
Switch Types	N.C., N.O., or Double throw, no neutral position
Electrical Connections	J7 . . . screw type terminals on switch standard J40 . . . solder type terminals on switch standard
On-Off Switch Differential	Fixed and uniform throughout specified range is standard
Mounting	J7 . . . ¼" NPT female, brass fitting standard J40 . . . ⅛" NPT male, brass fitting standard
Variations	Design variations are available upon specification
Applications	On industrial equipment and engine applications . . . marine, aircraft or special purpose

Although **UNITED ELECTRIC** *offers a complete line of temperature, pressure and vacuum controls . . . UE application engineers specialize in solving unique problems.*

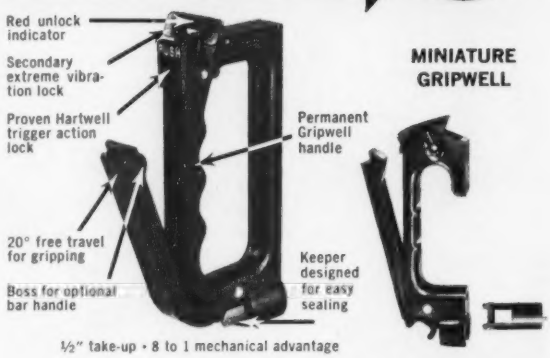
Send for full particulars today. Bulletins available upon request. Type J7 . . . Bulletin No. 5-7, Type J40 . . . Bulletin No. 5-9

United Electric Controls COMPANY

91 SCHOOL STREET, WATERTOWN, MASS

Circle 622 on Page 19

WHEN QUALITY IS YOUR TARGET...
THE GRIPWELL ELECTRONIC CHASSIS LATCH HELPS YOU HIT THE BULLSEYE


Red unlock indicator
Secondary extreme vibration lock
Proven Hartwell trigger action lock
20° free travel for gripping
Boss for optional bar handle
Permanent Gripwell handle
Keeper designed for easy sealing
MINIATURE GRIPWELL

½" take-up • 8 to 1 mechanical advantage

GRIPWELL® ELECTRONIC CHASSIS LATCH

A handsome, strong and durable handle latch to fasten "plug-in" type electronic chassis, providing for positive ejection and injection of the chassis and allowing an eight to one mechanical advantage, with a total one-half inch take up.

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Offices: Chicago · Ft. Worth · Hackensack · Seattle · Wichita

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SPLIT-SECOND TIMING
with the NO-FILAMENT-TUBE ELECTRONIC TIMER

Instant Timing — cold-cathode tube requires no warm-up.
Immediate Recycling — no recharge time needed for capacitor.
Flexible Arrangements — four models with many circuit features.
Short-time Intervals 1.5, 3, 6, 12 sec. standard; 0.2, 0.5, or 24 seconds on special order.

CK Model C

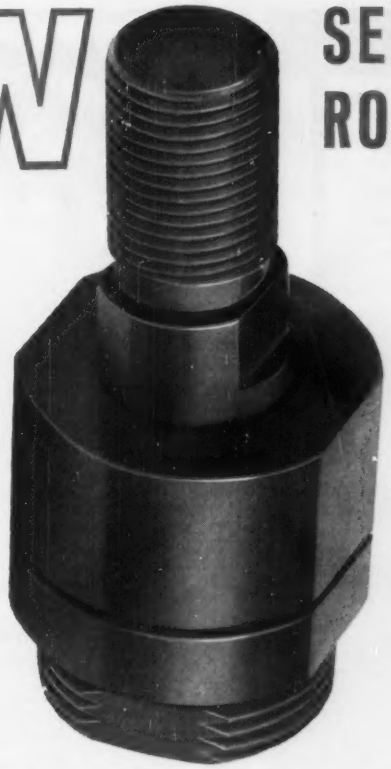
Easy Setting — short intervals can be spread over entire dial.
Eight-ampere Contacts — single-pole double-throw load.
Small Size — 3⅞" wide × 4⅜" high × 2" deep.
Low Cost — Model A . . . . . $29.00 list
Model C shown (momentary-contact start) . . . . . 32.00 list
Special features built-in on all models at nominal cost.

Write for complete information on Farmer Electronic Timers; and the CK Electronic Relay that will pick up impulses too short to operate a mechanical relay directly.

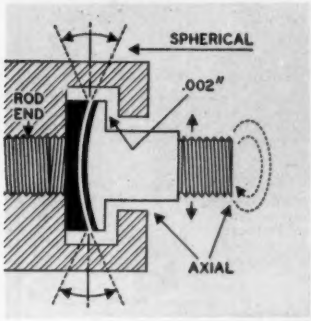
FARMER ELECTRIC
Products Company, Incorporated
2300 WASHINGTON ST. NEWTON LOWER FALLS, MASS.

Circle 624 on Page 19

NEW SELF-ALIGNING ROD END COUPLER



Spherical movement (on push only) and axial movement provide precision alignment between cylinder and machine. Couplers shipped with .002" clearance between floating head and shoulder of retaining nut.



- Reduces cylinder bearing wear caused by side loads and binding
- Compensates for machinery deflection due to weight shifts
- Saves cost and time of custom-designing special assemblies
- Allows greater machinery tolerances
- Simplifies machine installation, either OEM or on the job
- Fits all air and hydraulic cylinders built to industry standards
- Male or female couplings. Female thread mates with standard style No. 2 cylinder piston rods
- Immediate delivery from stock of couplers for ⅝, 1, 1⅜, 1¾, 2, and 2½-inch diameter rods. Also available for 3, 3½, 4½, and 5½-inch rods.

HYDRO-LINE HL

5602 PIKE ROAD, ROCKFORD, ILLINOIS manufacturers of: high- and low-pressure hydraulic cylinders • heavy-duty air cylinders • adjustable-stroke cylinders • dispensing cylinders • intensifiers • single-acting cylinders • booster cylinders

Circle 625 on Page 19

Designing or Re-designing?

for ☐ Lower Costs?
☐ More Sales Appeal?
☐ Improved Quality?

You'll find the answer in Die-cast Parts by DOLLIN

LOWER COSTS! Amazing savings in piece costs—secondary operations—combining of parts—finishing costs—assembly costs are made by using DOLLIN die-cast parts in place of other methods.

SALES APPEAL! Intricate exterior shapes and designs—complex interior holes, bosses, studs, sections, wall thicknesses are automatically produced—all in one shot! Wide choice of plating, buffing, polishing and finishing may be applied.

IMPROVED QUALITY! DOLLIN die-castings meet strictest specs for clean, sound, on-size, on-grade castings. Zinc die-castings are produced under the C-Z Certified Zinc Alloy Plan, aluminum castings are spectographically checked.

DOLLIN DC
Zinc and Aluminum
DIE-CASTINGS

Submit prints or samples of parts for engineering advice and quotation, without obligation. Write for facilities brochure.

DOLLIN CORPORATION
612 So. 21st St., Irvington, N. J.
See "Yellow Pages" for nearest office

Circle 626 on Page 19

160

Why wait for delivery on spiral bevel gears? ARROW ships from a full stock of common sizes, in ratios: 1 to 1 • 2 to 1 • 3 to 1 • 3 to 2 and 4 to 3. Gear sizes of 1.000 to 13.000 pitch dia. Teeth are precision matched, case hardened and crown lapped. Sets are precision made, high speed tested.

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Circle 627 on Page 19

Send for official entry blank . . .

To: Copper & Brass Research Association MD
420 Lexington Ave., New York 17, N.Y.

Please send me _____ entry blank(s) for 1961 Copper and Brass Achievement Award competition.

Name_____

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CATEGORY 1 *Industrial*

CATEGORY 2 *Architectural*

These annual awards honor outstanding contributions to advancing the use, application or metallurgy of copper, brass or other copper-base alloys. All entries must be received by March 31, 1961. Use coupon to get complete details and entry blanks.

1st prize in each category . . . $500 plus bronze award

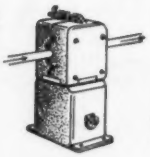
Circle 628 on Page 19

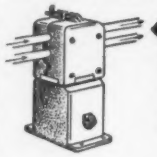
PUMPING IDEAS

POSSIBLE ONLY with a SIGMAMOTOR PUMP

MOVE CORROSIVE LIQUIDS

Material being pumped never comes in contact with pump mechanism. Wave-like motion of steel fingers forces material through Tygon tubing. By changing size of tubing, capacity can be increased or decreased. Pump housing opens for removal and insertion of tubing.



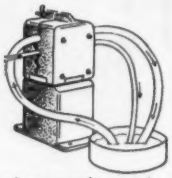


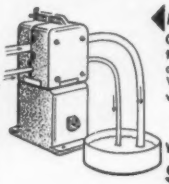
PUMP 2 OR 3 DIFFERENT LIQUIDS SIMULTANEOUSLY

Some models will accommodate up to four tubes so that four different liquids can be passed through the pump at one time without danger of contamination.

FEED AND MIX

One or more tubes can be feeding material to a mix while a larger tube is recirculating the liquid to produce agitation and thorough mixing. Viscous materials can be pumped without danger of gumming or plugging. Remove tube and pump is clean.





METER ADDITIVES

One or more additives can be pumped to a solution in the exact amount desired by selecting the correct size of tubing and regulating pump speed. Various controls can be incorporated to close valves ahead of pump.

Capacities from 0.5 cc. per min. to 4.5 G.P.M.

Write for complete information on sizes and capacities.

SIGMAMOTOR, INC.

26 N. Main Street • Middleport, N. Y.

Circle 629 on Page 19

Is This Job for You?

BACKGROUND—Recent degree in mechanical or electrical engineering. About three years of design-engineering experience.

ABILITIES—Able to evaluate technical information on design techniques, new machines, components. Provable ability to write clearly and accurately. Should work well with people, have initiative and imagination, demonstrate creative as well as practical ability.

ENVIRONMENT—Cleveland, Ohio, with some out-of-town travel. As assistant editor on MD's staff of 21 engineer-editors. In Penton Publishing Company, a growth company, with 5 magazines and some 60 editors.

COMPENSATIONS—Salary comparable to that in industry. Chance to grow within the company. Unusual opportunity to broaden education, experience, and contacts. Stimulating work.

If this appeals to you not merely as a job but as the basis of a career, write at once (with all pertinent facts) to the Editor, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

The Most Compact Solenoid Valve in the Fluid Power Control Field...

VERSA SERIES "A"

Versa's new four-way solenoid valves measure only 5½" high by 1⅝" diameter, yet have a full 3/16" diameter flow area. Completely corrosion-resistant and simple to install, Versa Series "A" solenoid valves are available in over 100 different variations. Triple pressure and functionally tested under water for guaranteed leakproofness.

VERSA

Write today for your free copy of Bulletin #1259

VERSA PRODUCTS COMPANY INC.
150 M COOLIDGE AVENUE
ENGLEWOOD, NEW JERSEY

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Available in Stainless Steel, Brass, Aluminum and Steel

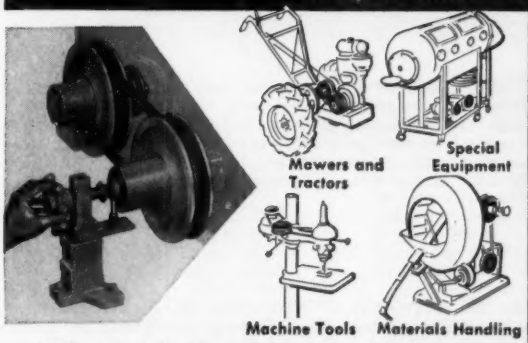
JACOBSON NUT MFG. CORP. Kenilworth, New Jersey

Circle 631 on Page 19

SPEED SELECTOR

VARIABLE PITCH SHEAVES

Control Speeds on Variety of Machines



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Circle 632 on Page 19

REPLACEABLE Spring Motors in Gleason Reels

Spring motors in GLEASON SPRING REELS are *replaceable* as a single unit by removing a few bolts. There's no chance of spring "fly out," no need to handle loose or free springs. A stock of these spring motors is always on hand, for quick replacement without difficulty or danger.

Check into this—and many other features, that make GLEASON REELS the safest, most efficient, most economical for all cable-control applications to "equipment in motion."

Your "Reel" problems can be most effectively solved by GLEASON REELS. Write for a Gleason-engineered suggestion — or free copy of Bulletin C-253.

Gleason Reel Corp.
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Dept. B
SPRING REEL HEADQUARTERS FOR ALL INDUSTRY

Circle 633 on Page 19

MECHANICAL ENGINEERS

Bausch & Lomb

There are several openings for Senior Design Engineers in the Product Design sections of our company.

These openings are permanent positions requiring the ability to take Mechanical Design responsibility from specifications to a saleable product. Products involved are mechanical-electrical-optical in nature. A Mechanical Engineering Degree and at least 6 years of mechanical design experience is required. No optical or electrical background is necessary, but would be helpful in certain openings.

These positions require board design, coordination of customer requirements with Electrical and Optical Designers, supervision of detail draftsmen, assistance to shop during construction and assembly as well as testing and development work.

Those who can qualify and are interested in real design responsibility are invited to submit a resume to: Mr. H. A. Frye, Professional Employment.

Bausch & Lomb
INCORPORATED
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MECHANICAL ENGINEERS

BRUNSWICK CORPORATION is expanding its Research and Development Division and offers outstanding career opportunities for graduate Mechanical Engineers qualified to handle positions involving

- **AUTOMATIC MACHINERY DESIGN**
- **PRODUCT DESIGN and DEVELOPMENT**

This is an opportunity to associate with a company recognized as a leader in the recreational field, and whose growth and stability has been outstanding. Positions offer good opportunities for technical advancement and long-range careers. Openings available at various levels from recent college graduates, Senior Design and Project Engineers to Engineers who have supervisory experience. New and modern engineering offices offer excellent work environment. The company is located in Western Michigan, "Heart of Michigan Vacationland" offering excellent opportunities for family recreational activities. Positions offer challenging work, attractive starting salaries commensurate with experience, along with excellent fringe benefits.

Send replies outlining education, experience, and salary desired, to A. J. Nelson.

Brunswick
CORPORATION
MUSKEGON, MICHIGAN

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ENGINEERS
AVAILABLE OR WANTED

WANTED: Graduate mechanical engineer experienced in steam trap, temperature regulator and heating specialties design and field amplification. Experience in heating processes and power piping knowledge desirable. Location—Eastern Middle Atlantic States. Address Box 981, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: HYDRAULIC ENGINEER. Excellent opportunity for applicant having the following qualifications. Ability to design and develop hydraulic circuits and components for applications on machine tools. Familiarity with servo-systems and numerical controls systems will be useful. Background should include engineering degree and two or more years of related hydraulic experience. Liberal benefits, stable employment and excellent community advantages. Location, North Eastern U. S. Please submit resume and salary requirements to Box 980, MACHINE DESIGN, 1213 West Third Street, Cleveland 13, Ohio for prompt reply.

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BPA NBP

backtalk——

—What Makes Sammy Run?

You'd run too, if your future held the terrors in store for this fellow: Any day he may have a serious automobile accident, ride a rocket sled, or be parachuted or ejected from an airplane—and maybe dumped into the sea. One of a long line of accident-prone anthropometric/anthropomorphic dummies—all named Sierra Sam—he does these things in the interest of humanity, to let designers know what would happen to a real man subjected to the same forces.

Sierra Engineering Co. begat its No. 1 Sam in 1949 at the request of the Air Force; since then thousands of Sams have taken part in thousands of military and civilian catastrophes. From his neoprene toes to his FM voice (he is articulate as well as articulated), Sam is a mighty interesting guy. Read about him in the Engineering News pages of the next issue of MACHINE DESIGN.

—'Tis the Season, Almost

Although it's about two weeks too early for most American males to start their Christmas shopping, we want to bring to your attention a couple of gifts for the Little Woman that may appeal to engineer-type buyers.

"Electronic" charms, including a yule tree with a glowing star at the top and a beaming Santa Claus, are made with miniature batteries and bulbs. These two 14-K Christmas charms, plus four others, are yours on a gold chain for $337.

For the lady who has everything, including an itchy back, there is an electric back scratcher. Billed as the first new idea in this field since the Ming dynasty, this $4.98 gadget has a little motor that causes the traditional hand to vibrate at the rate of 3000 times per minute. Fastest scratcher in the West, we'll wager.

—Red Journalism

We have a news release from our Department of Commerce announcing a Russian-English translation of a dictionary of 1500 Russian operational, tactical, and general military terms. While this volume is not of particular interest to either you or us, we mention it because of its unusual informative qualities: Both the Russian military experts who reviewed it and the U. S. Army translators point out that the dictionary contains "omissions, inaccuracies, repetition, and confused definitions."

Next, the good comrades will claim that they invented misteaks.

—Cupreous Contest

The third annual competition honoring outstanding contributions to advancing the use of copper and its alloys has been announced by the Copper & Brass Research Association. Two first awards ($500 and a bronze trophy) will be given to winners in both Industrial and Architectural categories. Entries for the Industrial Award may include new products, redesign or original concept for established applications, marketing or promotion programs, new production processes, or contributions to science and research that significantly involve the use of copper metals. Entries must be submitted before March 31, 1961, to Copper & Brass Research Association, 420 Lexington Ave., New York 17, N. Y.

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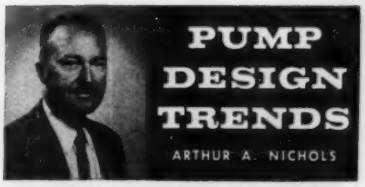

SPECIAL PURPOSE PUMPS FOR SPECIAL PROBLEMS

► In over thirty years experience in the design and manufacture of special pumps, we have solved numerous pumping problems where the design and production of a suitable pump was considered almost impossible, either because of the material to be pumped, or because of the precise manufacture necessary to obtain satisfactory performance.

► **Nichols pumps are standard for example, in the synthetic fibre industry for pumping rayon, acetate, celanese, nylon and other fibres spun in synthetic fibre plants throughout the world.**

► Some interesting new applications for Gerotor pumps have been developed in recent times involving specialized problems in hydraulic servo systems.

► **Important advantages are offered by the Gerotor pump for servo control applications. It is a positive displacement pump and provides a smooth power flow from one end of the pumping cycle to the other. Unlike other types of pumps which tend to quit work at the low end of the speed range,** *Gerotors stay right on the job and provide positive power to the extremely low range.* **Thus, they are exceptionally responsive in servo systems.**

► For electronic equipment operating at high altitudes, air cooling of high input components becomes troublesome because lower air density limits cooling fan efficiency. Liquid cooling systems are therefore frequently preferred for this type of service. Our extensive experience over the years in the production of high performance aircraft engine pumps has been of great value in developing electronic coolant circulators that provide maximum weight and space savings with efficient heat transfer capabilities.

► **Special pumps have been designed and manufactured for applications as varied as metering pumps in vending machines and conveying molten solder in production equipment. This long and varied experience in industry-wide pumping applications, combined with years of specialized development and production of pumps for the aircraft engine, super-charger, missile, helicopter and electronic field is available to today's designer faced with new and unusual pumping applications and problems.**

► *Technical data is available and your inquiry is invited. Write:*

W. H. NICHOLS CO.

Makers of Zenith Metering Pumps and the Nichols Milling Machine "the miller that uses its head".

48 WOERD AVE., WALTHAM 54, MASS.

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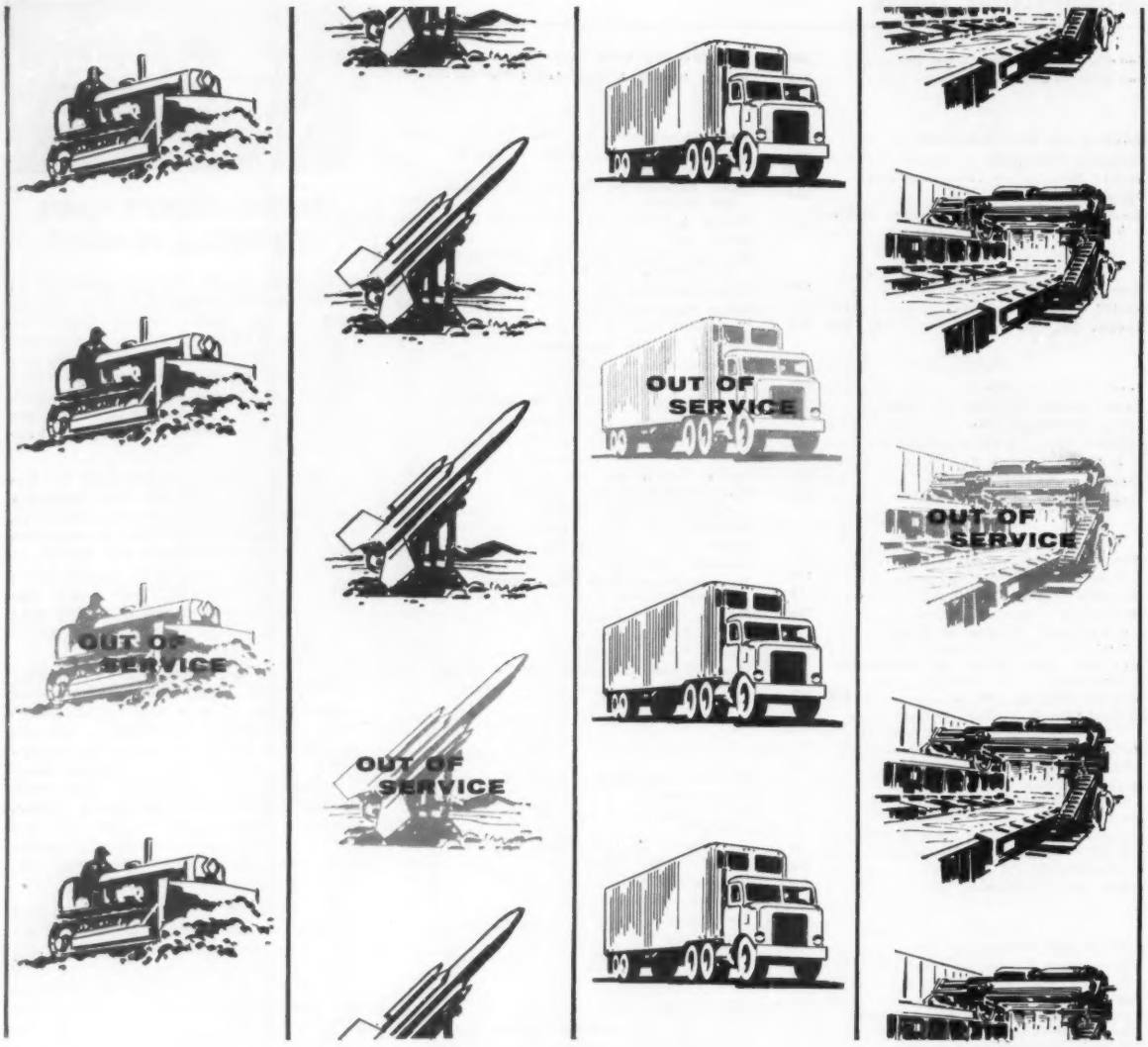


Dependable ROLLWAY BEARINGS

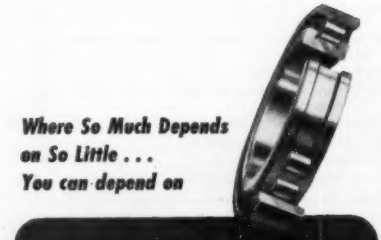
help keep your down-time low

When a bearing "goes", your machine stops.

That's why it pays to call in Rollway. Especially when reliability is a must.

At Rollway, you can choose from a wide selection of sizes and types with maximum capacities . . . for normal, low or high temperature operation. All meeting or exceeding RBEC requisites in Classes 1 to 5.

You'll find that Rollway meets your needs exactly – in commercial grade, precision, or ultra-precision bearings. To get the bearing you want in a hurry, or to start R and D on the bearing you've been dreaming about, just call or write Rollway Bearing Company, Inc., Syracuse 1, New York.



Where So Much Depends on So Little . . . You can depend on

ROLLWAY BEARINGS

Radial and Thrust Cylindrical Roller Bearings

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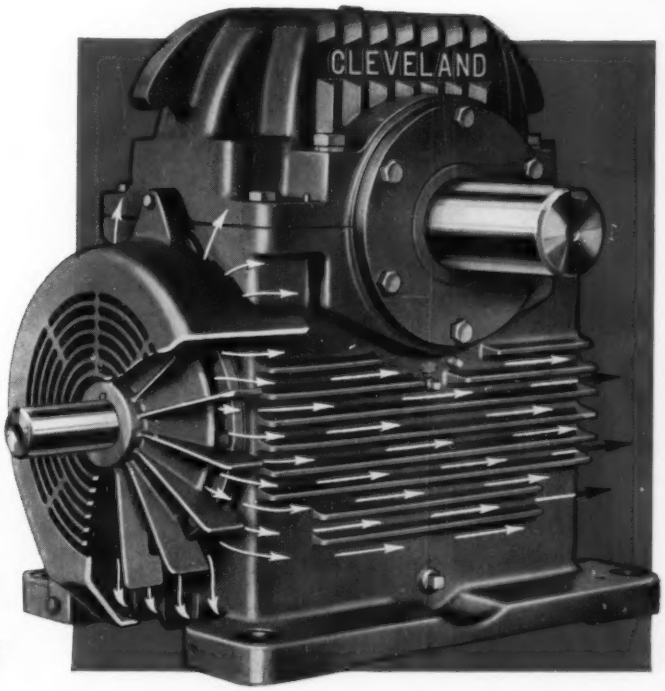


Fan cooling for Increased HP Capacity is Not New... *to users of Cleveland Speed Reducers*

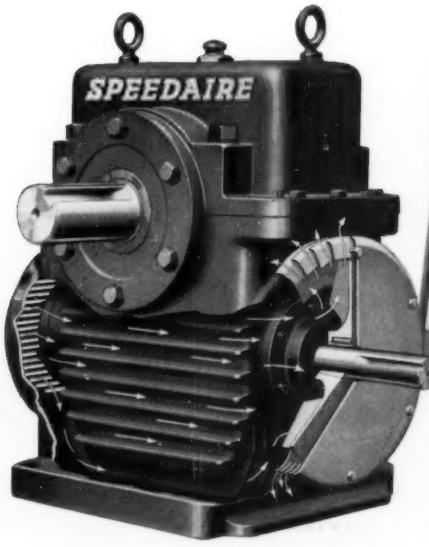
As far back as 1944, Cleveland Speedaire Worm Gear Reducers (shown in both the announcement ad and cutaway photo below) were providing industry twice the load carrying capacity then available from standard worm gear units of equal frame size. Even then, it was *fan cooling* that did the trick—because fan cooling was and still is the most practical method of heat dissipation.

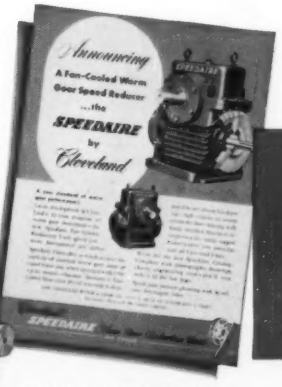
On the new, higher horsepower Cleveland's (shown in top cutaway photo), a small, specially designed fan—equally effective in either direction of rotation—is located on the worm shaft's input side. Fan size and design permit a smooth, more effective flow of air beneath, above, and around all sides of the reducer.

Mounting the cooling fan on the WORM shaft input end is a very definite Cleveland advantage for when the fan is mounted on the *opposite* side, a second oil seal is needed. This results in additional friction loss due to seal drag—and is another point where oil leakage could occur.

Remember, it was Cleveland design engineers who pioneered both fan cooling and centrifugal casting of bronze gears—and after sixteen years of rugged field usage in all types of industrial plants, have now incorporated these features in all units (from 3 to 12-inch centers) of the new standard Cleveland Speed Reducer line.

Get the story of these new speed reducers from your Cleveland representative, or write today for free 36-page illustrated Bulletin No. 410 that contains complete engineering information. Either way, you will get the answer to improved speed transmission—at savings of 50% or more on per horsepower cost!





A 1944 CLEVELAND AD
"Announcing A Fan-Cooled Worm Gear Speed Reducer ... SPEEDAIRE."

CLEVELAND
Worm Gear
Speed Reducers

Cleveland Worm & Gear Division
Eaton Manufacturing Company
3287 East 80th Street • Cleveland 4, Ohio

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C/R did the trick...

Specially compounded and molded parts gave this manufacturer the competitive edge he wanted!

Hydro-Line Manufacturing Company posed this problem to C/R: produce an elastomer rod seal and dirt seal with the highest possible resistance to wear (equal or superior to Buna-N) — that will function dependably in air at temperatures ranging from -40° to 450° F. Further, the seals must be compatible with the widest range of industrial hydraulic fluids.

C/R† Sirvene engineers selected Viton-A* as the base material. They specially compounded it, pigmented it to permit distinct color-coding, then molded the rod seal and auxiliary dirt seal you see above to precise tolerances. These seals have wear-resistance equal or superior to Buna-N. They have the highest continuous service temperature resistance of *any* elastomer on the market, and their compatibility will assure long service life in virtually all industrial applications. The manufacturer is able to standardize — safely and economically.

C/R† can do the same for you. We have the special techniques, knowledge and facilities to help you give your product a competitive advantage. Call or write for immediate information or engineering assistance.

*DuPont registered trademark
†T.M. Reg. U.S. Pat. Off.

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C/R®

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